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Aura Spacecraft Ephemeris and Attitude Data Preprocessing

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Abstract

This document describes the operations performed by the Drop 6A Aura (formerly CHEM) DPREP (Data Pre-Processing), versions 0.0.10 and later, to produce the Aura SDP Toolkit ephemeris and attitude granules. The SDP Toolkit EPH tools, in deriving ephemeris and attitude for the Aura platform, use these granules.

The audience for this document includes the Instrument Teams, DAAC operators, Test Team, and Toolkit Team.

Keywords: Drop 6A, DPREP, Aura

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Contents

Abstract

Contents

1. Data Preprocessing

2. FDD Ephemeris Preprocessing

3. EMOS Attitude Preprocessing

4. Interface Between Toolkit Granules and Data Processing Software

5. DPREP and the DAAC Operator

List of Figures

List of Tables

Appendix A. DPREP Error Codes

Abbreviations and Acronyms

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1. Data Preprocessing

1.1 DPREP

1.1.1 Overview

DPREP is the generic term for a product generation executable (PGE) that converts spacecraft ephemeris and attitude data to standard form for use by the EOSDIS Science Data Processing (SDP) Toolkit. DPREP has a standard set of functionality requirements that must be met, regardless of platform (i.e. Aura), namely at a minimum, the following items:

1. Produce ephemeris and attitude granules in Toolkit and HDF format (Sections 1.3, 1.4, 2, and 3), for use by the SDP Toolkit and, thus, eventually by the Science PGEs (Section 4).
2. Perform platform-generic data quality analyses on the ephemeris and attitude data streams (Section 1.2.1). The time-order of data records is verified; records cannot be out of order, be at duplicate times, or fall outside the processing time-range. (Section 1.2.1.1). DPREP also verifies that each ephemeris and attitude data point falls within the acceptable range (Section 1.2.1.2), checks for the presence of spikes (Section 1.2.1.3), checks for the presence of data gaps (Section 1.2.1.4), and checks for continuity across data segments (Section 1.2.1.5). DPREP also assures the integrity of the QA analysis process (Section 1.2.1.6).
3. Repair ephemeris and attitude records that have been flagged for data quality violations thus filling short gaps in the ephemeris and attitude data streams. Aura does not require data repair to be done on its ephemeris and attitude data streams (Section 1.2.1.7).
4. Perform platform-specific data quality analyses on the ephemeris and attitude data streams (Section 1.2.1.8).
5. Set quality flags in each ephemeris and attitude data record generated by DPREP to denote the quality of data contained therein (Section 1.2.1.9).
6. Place a request for replacement data if data quality analysis discovers an unacceptable number of violations (Sections 1.2.2 and 5.3).
7. Produce metadata, including QA summary metadata (Section 1.2.1.10) and orbit metadata (Section 1.3.4).
8. Recover from failed DPREP PGE processing (Section 5.4) and resume processing after a period of data dropout (Section 5.2).
9. Process replacement ephemeris and attitude data (Section 5.3).
10. QA consistency checking (Section 1.2.1.1).

1.1.2 DPREP Data Throughput

Generally, DPREP provides the means for transforming a wide variety of raw ephemeris and attitude formats from various spacecraft to a standard format for use by the SDP Toolkit EPH

tools. This implies that DPREP has to be tailored, or even partly rewritten, for new spacecraft as they are added to the program. Thus far, DPREP software has been written for TRMM, Terra, Aqua (now operational), and Aura (to be launched in 2004). At a minimum the SDP Toolkit EPH tools expect:

1. Ephemeris and attitude granules in Toolkit or HDF format.
2. Position and velocity vectors in the Mean-of-J2000 reference frame,
3. Euler angles in the instantaneous orbital reference frame. Euler angles are in radians, in the order given by the Euler angle order in the metadata (the order is in the granule header).
4. Position vectors in meters.
5. Velocity vectors in meters per second.
6. Projection of the spacecraft angular velocity in the Mean-of-J2000 inertial reference frame on the body axes, in radians per second. The order is roll rate, pitch rate, yaw rate.[1] These data are sometimes loosely called "attitude rates," though they are not the rates of change of the Euler angles.
7. Each ephemeris and attitude record, tagged with Toolkit-format timestamps.
8. The quality of each Toolkit ephemeris and attitude record evaluated and summarized in its data quality flags, one for ephemeris and one for attitude.
9. A set of granule metadata for each Toolkit ephemeris and attitude granule generated.

DPREP produces two data streams, one for ephemeris and one for attitude data, from two different sources (see Section 1.2 and Figure 1-1). The ephemeris and attitude granules are produced in two formats, Toolkit and HDF format. Toolkit and HDF-formatted granules conform to the internal format defined for use by the Toolkit EPH tools, namely PGS_EPH_EphemAttit and PGS_EPH_EphAtt_unInterpolate. The HDF-format granules allow, in principle, transport of ephemeris and attitude data between hardware platforms.

The Toolkit and HDF-format ephemeris and attitude granule timestamps are in TAI93 format, the elapsed time in seconds from January 1, 1993, 0h UTC, including leap seconds. The resolution of this time is better than a microsecond; thus the accuracy limit is the Aura clock. The reference frame for the ephemeris granule position and velocity vectors is Mean-of-J2000. When necessary, position and velocity vectors are transformed to Mean-of-J2000 using SDP Toolkit CSC routines as required; Euler angles are referenced to orbital coordinates. Refer to Figure 6-3 in Section 6.3.3 of the SDP Toolkit User's Guide. For Aura, the position and velocity are received in Mean-of-J2000 so no change of frame is needed.

See EOSDIS Spacecraft Ephemeris and Attitude Data Specification: Contents and Structure (P. Noerdlinger et al, 1999) for a description of the Toolkit file content and format, data quality flags content and format, and required granule metadata. This document is available on the World Wide Web at http://newsroom.gsfc.nasa.gov/sdptoolkit/appendl.html and is summarized in the

[1] This applies to Aura and later spacecraft; for TRMM the angular velocity was defined in the orbital reference frame.

Release 6A.07 SDP Toolkit User's Guide for the ECS Project, Appendix L (document number 333-CD-605-003, April 2003 draft and later).

1.2 Aura DPREP

Aura DPREP has two sources of ephemeris and attitude data. These sources are:

1. FDD-supplied ephemeris from ground-based range data.
2. EMOS-supplied attitude from spacecraft housekeeping data.

The incoming and processed data files from these two sources need not be in synchrony as to their start and stop times. Data stream (2) will preserve original spacecraft clock time, whose nominal data interval is one second. DPREP does not alter Aura data record times other than by translation of format to TAI93 (for times within records and certain metadata) or to CCSDS standard ASCII format A, when required for metadata. See EOSDIS Spacecraft Ephemeris and Attitude Data Specification: Contents and Structure for details. This document can be found on the World Wide Web at http://newsroom.gsfc.nasa.gov/sdptoolkit/appendl.html and is summarized in the Release 6A.07 SDP Toolkit User's Guide for the ECS Project, Appendix L (document number 333-CD-605-003, April 2003 draft and later).

Aura DPREP uses two PGEs to convert data from the ephemeris and attitude data streams identified above to SDP Toolkit ephemeris and attitude data. The DPREP PGEs, respective of data stream, comprise:

1. EcDpPrAuraEphemerisDPREP_PGE (FDD Ephemeris)
2. EcDpPrAuraAttitudeDPREP_PGE (EMOS Attitude)

The first PGE processes *ephemeris* data from FDD. The second PGE processes *attitude* data from EMOS. Ephemeris data must be processed prior to attitude data.

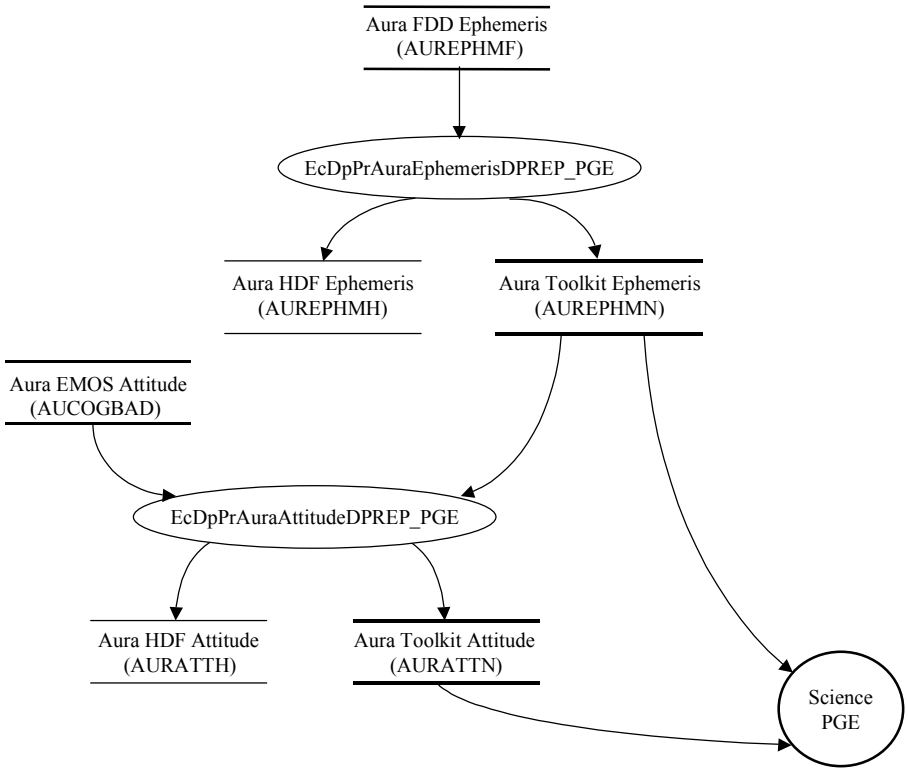

Figure 1-1. Aura DPREP Processing Data Flow

1.2.1 Aura DPREP Data Quality Analysis

In general, DPREP performs data quality analysis (QA) using moving windows that independently scan the ephemeris and attitude data streams. The QA window defines the set of data used in QA analysis; these are the data on which statistical analyses are performed when determining data quality. The QA window must contain at least a user-specified minimum number of data records and no more than a maximum number of records. The minimum and maximum number of records differs for the ephemeris and attitude data streams. Table 2-1 and Table 3-1 outline the QA analysis parameters used by each DPREP PGE.

The QA window always contains an odd number of records, with the record in the middle of the window undergoing QA analysis. During normal QA analysis 1) the QA window moves one record down the data stream, 2) QA analysis is performed on that record, and 3) QA results get recorded in the data quality flag for that record. The process repeats for each record in the data stream.

For Aura DPREP, the size of the QA window is three records and cannot be overridden with a user-specified window size. A window of three data points contains the record undergoing QA analysis and the immediately preceding and following records. Because FDD and EMOS have preprocessed the ephemeris and attitude data streams, these data streams are not in need of the full array of QA analyses performed by DPREP. As a result, neither the ephemeris or attitude data streams have limit analysis nor data repair performed; only limit analysis and data repair requires the QA window to have a substantial number of data points within it. Refer to Sections 1.2.1.3 and 1.2.1.7 for more information. Furthermore, because limit analysis is not performed, QA analysis cannot fail; therefore, flagging of data for having failed to establish its quality cannot occur. See Section 1.2.1.6 for more information. Of the standard QA analyses performed by DPREP, only consistency, range, data gap, and continuity checking are performed on the Aura ephemeris and attitude data streams.

QA analysis is performed on all data contained within the record and the data quality flag in that record summarizes the results. For example, an ephemeris record's timestamp, position vector, and velocity vector all undergo QA analysis. Both the position and velocity are subject to the same QA analyses (typically limit and range; for Aura, only range) that result in red high/low and/or yellow high/low violations. Quality flag design permits the recording of red high/low and/or yellow high/low violations only; position and velocity violations, as well as, limit and range violations cannot be distinguished. The quality flag can only note that a violation has occurred, but not the type of violation (limit and range) or in which data element (position or velocity) the violation has occurred. The same holds for the Euler angles and angular velocities found in the attitude record. As mentioned before, the FDD-supplied ephemeris data stream has had a substantial amount of preprocessing performed. Users should never see red or yellow flag nor gap flag bits set because FDD preprocessing of the ephemeris data removes inconsistencies indicated by these flag bits. For this reason, the ephemeris data stream is expected to be error free and remain non-flagged. By and large, this is true of the attitude data stream as well. EMOS preprocessing does not fill gaps in the attitude data stream, however. Consequently, data gaps can be expected in the attitude data stream. Quality flags Table 1-1 outlines the data quality flag bit description as defined for the Aura platform.

The EMOS-supplied attitude consists of two data streams that are subject to QA analyses: 1) the attitude data stream and 2) the Status Word 2 data stream. The attitude data stream contains the attitude of the Aura platform, in quaternions, at a nominal data interval of one second. The Status Word 2 data stream contains the mode that the on-board attitude system was in (i.e. *fine point*) when the attitude of the Aura platform, contained in the attitude data stream, was recorded, at a nominal data interval of eight seconds. The differing nature of these two data streams leads to a different set of QA analyses being performed on them. DPREP performs consistency checking, range analysis, data gap analysis, and continuity checking on the attitude data stream while DPREP performs only consistency checking, data gap analysis, and continuity checking on the Status Word 2 data stream. Moreover, the dependence of the attitude data stream on both the Status Word 2 data stream and the ephemeris data stream results in a unique set of platform-specific QA analyses being performed by DPREP. See Section 1.2.1.8 for more on the processing of the EMOS attitude and Status Word 2 data streams.

Parameters controlling QA analysis are specified in the PCF and saved in the header of all DPREP products. See Table 2-1 and Table 3-1 for a description of PCF parameters recognized by each DPREP PGE. EOSDIS Spacecraft Ephemeris and Attitude Data Specification: Contents and Structure (P. Noerdlinger et al, 1999) describes where in the DPREP products, and in what order, the QA analysis parameters are saved. This document can be found on the World Wide Web at http://newsroom.gsfc.nasa.gov/sdptoolkit/appendl.html and is summarized in the Release 6A.07 SDP Toolkit User's Guide for the ECS Project, Appendix L (document number 333-CD-605-003, April 2003 draft and later). The values of these parameters are suggested and can be changed, if so desired, by the Science Team. To change the value of a QA analysis parameter, it must be changed in DPREP PGE ODL prior to PGE registration.

The QA summary metadata reflect the percentage of missing, repaired, and out-of-bounds records within granules produced by DPREP. See Section 1.2.1.10 for more information regarding QA summary metadata.

Table 1-1. Aura Data Quality Flag Bit Description (1 of 2)

Bit	Bit Assignment	Description
0	Overall Quality Summary	Set if any quality check is failed; unset for ideal data. Data point can still be useful even if this bit is set; scrutiny of the other bits would be required however. Bits 1 and 16 are unset in this instance of ideal data.
1	Data State Summary	Set if any generic data quality bit is set (bits 2 - 11)
2	Red Limit Low Exceeded	Low red limit has been exceeded.
3	Yellow Limit Low Exceeded	Low yellow limit has been exceeded.
4	Yellow Limit High Exceeded	High yellow limit has been exceeded.
5	Red Limit High Exceeded	High red limit has been exceeded.
6	Long Data Gap Follows	A significant data gap follows this data point.
7	Short Data Gap Follows	A minor data gap follows this data point.
8	Short Data Gap Precedes	A minor data gap precedes this data point.
9	Long Data Gap Precedes	A significant data gap precedes this data point.
10	Point is a repaired data point	Used for points inserted by DPREP prior to Toolkit use (interpolated).
11	Quality flag problem	Quality data not available (bits 0-5 not meaningful)
12	No data available	SDP Toolkit unable to find data at the requested timestamp.
13	Unassigned	Reserved for SDP Toolkit use.
14	Interpolated data point	SDP Toolkit interpolation used to derive data point.
15	Unassigned	Reserved for SDP Toolkit use.
16	Platform-Specific Fatal Flag	Set if any fatal platform-specific quality bit is set.
17	Bad Status Word	Attitude unprocessed due to invalid attitude system mode in Status Word 2 data stream.
18	Missing Status Word	Attitude unprocessed due to record missing in Status Word 2 timeline.
19	Bad Ephemeris Data	Attitude unprocessed due to poor-quality or unavailable ephemeris data.

Table 1-1. Aura Data Quality Flag Bit Description (2 of 2)

Bit	Bit Assignment	Description
20-22	Operating Mode	GN&C operating mode from Status Word 2.
23-25	Operating Mode Transition	Operating mode transition flag.
26-31	Unassigned	Available for other platform-specific data – quality or other.

When performing QA analysis on records close to a granule boundary in the ephemeris and attitude data streams, the QA window extends into the preceding or following data segments as circumstances dictate. This explains DPREP's dependency on granules from segments preceding and following the segment being processed. Records contributed to QA analysis from a preceding granule always come from the SDP Toolkit-format granule produced by the preceding DPREP process. Only those records that passed QA analysis are accepted from the preceding granule. On the other hand, records contributed by the following granule always come from the raw granule to be processed next by DPREP. Normally, DPREP processing lags one granule behind the most recently available granule that can be processed by DPREP. However, due to exceptional Aura DPREP processing requirements, this lag can be even longer. See Section 1.4.2 for more information.

In addition to the dependency on the granule from the preceding segment just described, EMOS attitude processing requires raw input from the preceding segment in order to complete QA analysis on the Status Word 2 data stream.

Initialization of QA analysis occurs on the very first mission granule or on the first granule following data dropout. This "boot-up" process is required whenever a preceding granule is unavailable with which to arrange quality checks across granule boundaries. The boot-up process requires QA analysis to be performed on each record found in the first half of the QA window immediately after window initialization. Only after the quality of the mid-record is determined can the QA window start moving down the data stream; the record undergoing QA analysis will always be in the middle of the QA window from this time onwards (ideally until the end of the mission). Of course the same situation occurs when terminating QA analysis at the end of the mission. The boot-up procedure can be chosen at any time during the mission, however (e.g. following a long period of data dropout). Boot-up is selected by scheduling Profile 2 of the DPREP PGE to be run (Profile 2 initializes DPREP processing following a period of data dropout. Profile 1 is for nominal DPREP operation. Profile 3 terminates DPREP processing prior to a period of data dropout. Profile 4 is for processing isolated granules.). See Sections 1.4 and 5.2 for more information.

1.2.1.1 Consistency Checking

DPREP performs consistency checks to ensure the integrity of the raw input data. These checks do not result in the setting of any data quality flags, however. On finding an inconsistency, DPREP aborts with an error message, which invokes the Failed PGE subscription. A manual request for replacement data is placed with FDD or EMOS once it is determined that DPREP aborted due to a consistency check failure. See Sections 5.3.1 and 5.3.2.

DPREP confirms that the following are true and aborts if any of the conditions fail:

1. Timestamps are time ordered.
2. Duplicate times do not exist.
3. Timestamps lie within the processing time-range.
4. The first and last data records match the start and end times recorded in the granule header. This check applies to FDD-supplied ephemeris data processing only.
5. The satellite ID in the FDD-supplied ephemeris matches the expected value found in the PCF. Furthermore, the product ID ("EPHEM"), tape ID "STANDARD", and source ID ("GTDS" or "AMPT") must match expected values.
6. The magnitudes of quaternions in the attitude data stream of the EMOS-supplied attitude are within the acceptable tolerance (currently ±1E-07) of one.

Ensuring that timestamps are time ordered, duplicate times do not exist, and timestamps lie within the processing time-range occurs on both the attitude and the Status Word 2 timelines found in the EMOS-supplied attitude.

1.2.1.2 Range Analysis

The magnitude of position and velocity vectors, as well as the attitude roll, pitch, and yaw angles and corresponding angle rates, must fall within a specific range of values in order to be valid. Data points that fall outside of the acceptable range get flagged for violating both red and yellow limits. *These data points should not be used in science data processing.* Data points that exceed the maximum limit are failed for red and yellow high limit violations (bits 4 and 5 in the data quality flag). Likewise, data points that fall short of the minimum limit are failed for red and yellow low limit violations (bits 2 and 3 in the data quality flag). Data quality summary bits 0 (overall QA summary) and 1 (data state summary) are set as well.

For Aura, the magnitude of the position vector must fall between 6,500,000 and 7,380,000 meters inclusive in order to be valid. The magnitude of the velocity vector must fall between 6,850 and 8,300 meters per second inclusive. Roll and yaw angles must fall between $-\pi$ and $+\pi$ inclusive while the pitch angle must fall between $-\pi/2$ and $+\pi/2$ inclusive. All angle rates must fall between -0.005236 and 0.005236 radians per second (-0.3 to 0.3 degrees per second) inclusive.

Range analysis is performed on the FDD ephemeris data stream and the EMOS attitude data stream but not on the EMOS Status Word 2 data stream. PCF logical IDs 5030 through 5033 specify the range limits for position and velocity vectors. Logical IDs 5040 through 5047 specify attitude angle range limits, and logical IDs 5036 and 5037 specify attitude angle rate range limits.

1.2.1.3 Limit Analysis (Checking for Spikes)

Because FDD and EMOS have preprocessed the ephemeris and attitude data streams, these data streams are not in need of the full array of QA analyses performed by DPREP. As a result, neither the ephemeris or attitude data streams have limit analysis performed. If the reader is

interested in how DPREP performs limit analysis, Terra Spacecraft Ephemeris and Attitude Data Preprocessing (document number 500-EMD-001) provides a detailed description.

1.2.1.4 Data Gap Analysis

Data gap checking looks for short and long data gaps that precede and follow the data record undergoing QA analysis. Hence a record can be flagged for *short gap precedes* (bit 8 in the attitude data quality field), *short gap follows* (bit 7), *long gap precedes* (bit 9), and *long gap follows* (bit 6). Typically a record is flagged for only one of the preceding conditions; an isolated record can be flagged for gap precedes and gap follows, however. Records that are flagged for gap precedes and/or follows can be used in science data processing. Data quality summary bits 0 (overall QA summary) and 1 (data state summary) are also set in the event that any of bits 6 through 9 are set.

Gap checks also bridge data segment boundaries. Consequently, DPREP processing depends on the availability of the raw input granule that follows the one being processed. Furthermore, DPREP depends on DPREP output produced from processing the segment immediately preceding the segment being processed when gap checking the FDD ephemeris and the EMOS attitude data timelines. DPREP also depends on the raw input from the segment immediately preceding the segment being processed when gap checking the EMOS Status Word 2 timeline.

In the FDD ephemeris and the EMOS attitude data timelines, a gap that is longer than one second gets flagged as a long data gap. Consequently, all gaps are considered long data gaps in these timelines (the data interval in the FDD ephemeris and the EMOS attitude data timelines is one second; hence any missing data constitutes a long gap). The presence of a long gap in the FDD ephemeris timeline causes DPREP to request replacement data from FDD via the Spatial Subscription Server; replacement data is requested as needed for the FDD ephemeris timeline. On the other hand, the presence of a long gap in the EMOS attitude data timeline does not cause DPREP to request replacement data from EMOS. The gap is flagged as a long gap and remains as such in the EMOS attitude data timeline; the subsequent delivery of replacement data from EMOS cannot fill the gap. Similarly, a data gap that is longer than eight seconds constitutes a long gap in the EMOS Status Word 2 timeline (the data interval in the EMOS Status Word 2 timeline is eight seconds; any missing data constitutes a long gap). Again, the presence of such a gap does not cause DPREP to request replacement data from EMOS. Instead, DPREP flags all attitude records that fall within the Status Word 2 gap for the missing status word condition. Refer to Section 1.2.1.8 for an explanation of the processing that is performed on the attitude and Status Word 2 data streams.

For the sake of timely forward processing (i.e. processing in near real-time) of FDD ephemeris, Aura DPREP foregoes gap checking of the ephemeris data timeline *between the segment being processed and the one immediately following*. Rather than wait 24 hours for the FDD ephemeris granule from the following segment to become available, DPREP omits gap checking at the following segment boundary. Because of this design feature, DPREP can detect such a data gap only when processing of the *following* segment completes. Subsequent data reprocessing detects and correctly flags data gaps not properly detected in forward processing.

Because DPREP can process granules that are not in time-order, non-existent long gaps might be accidentally flagged in the ephemeris timeline. In order to consistency check across data segment boundaries, DPREP depends on DPREP output produced from processing the segment immediately preceding the segment being processed. If the *immediately* preceding granule is not available, DPREP accepts the most recently available granule, up to seven days in the past. A long gap can be flagged between the segment being processed and the preceding segment. If the gap is filled by a subsequent delivery of the missing granule, a long gap is erroneously flagged in the ephemeris timeline.

Similarly, DPREP can fail to flag gaps that are actually present in the attitude timeline. If data from the preceding and/or following segments do not become available after a *36-hour* wait period, DPREP processing continues without input from these segments. Consequently, a gap that precedes and/or follows the segment that is being processed goes undetected if the preceding and/or following granules are not available within the 36-hour wait period. The need for FDD-supplied ephemeris in Aura attitude processing, and not the desire for preceding and/or following attitude granules for gap checking, imposes this lengthy wait. FDD-supplied ephemeris takes 24 or more hours to arrive, hence the wait. Because of the lengthy wait, all attitude data are expected to arrive on time. Nonetheless, DPREP behaves in the abovementioned manner if the arrival of attitude granules is delayed. See Section 1.4 for more on the DPREP processing scenario.

Subsequent data reprocessing corrects improper gap flagging at the segment boundaries: gap flags erroneously introduced as well as those that went undetected.

1.2.1.5 Continuity Checking

DPREP checks the continuity of the Aura ephemeris and attitude data streams across data segments: the segment that is being processed and the *immediately* preceding and following segments. DPREP does this by performing consistency and data gap checks that bridge segment boundaries. The aforementioned checks are initiated using data from the end of the *immediately* preceding segment and completed using data from the *immediately* following segment.

For the sake of timely FDD ephemeris processing, Aura DPREP foregoes continuity checking of the FDD ephemeris data stream *between the segment being processed and the one immediately following*. Rather than wait 24 hours for the FDD ephemeris granule from the following segment to become available, DPREP omits continuity checking at the following segment boundary. Because of this design feature, DPREP can ensure the continuity between these two data segments only when processing of the *following* segment completes.

The EMOS-supplied attitude contains two data streams: 1) the attitude data stream, with a nominal data interval of one second, and 2) the Status Word 2 data stream, with a nominal data interval of eight seconds. DPREP ensures the continuity of both of these data streams across data segments.

1.2.1.6 Failure of QA Analysis

If any process that supports QA analysis fails, the record undergoing quality analysis gets flagged for having failed to establish its quality.

Currently, QA analysis can fail for the following reasons:

1. The QA window does not contain the minimum number of records required for limit analysis.
2. The quadratic least-squares fit performed in limit analysis fails to determine the coefficients of fit because the system of equations being solved produced a singular matrix.

Failure of QA analysis can only occur when performing limit analysis. Because FDD and EMOS have preprocessed the ephemeris and attitude data streams, neither the ephemeris nor attitude data streams require limit analysis to be performed on them. Consequently, flagging of data for having failed to establish its quality cannot occur in the Aura ephemeris and attitude data streams.

1.2.1.7 Aura Data Repair

Because FDD and EMOS have preprocessed the ephemeris and attitude data streams, data repair has been deemed unnecessary and will not be performed. If the reader is interested in how DPREP performs data repair, Terra Spacecraft Ephemeris and Attitude Data Preprocessing (document number 500-EMD-001) provides a detailed description of the data repair performed on Terra's ephemeris data stream.

1.2.1.8 Aura Platform-Specific QA Analyses

All QA analyses discussed thus far are standard analyses that should be conducted by all invocations of DPREP, past, present, and future. How these analyses are achieved varies from platform to platform, but they nevertheless constitute analyses that should be performed, regardless of platform.

The data quality flag allows DPREP to indicate platform-specific data quality conditions, however. Bits 16 through 31 of the data quality flag are reserved for platform-specific quality analyses. DPREP developers, as requirements dictate, decide upon the meanings of bits 17 through 31. Bit 16, the Platform-Specific Fatal Flag, summarizes the activity of the remaining bits 17 through 31. The Platform-Specific Fatal Flag is set if and only if any of bits 17 through 31 are considered fatal for use in science data processing, and are themselves set.

There exist two data streams, apart from the attitude data stream itself, that influence the quality of the attitude produced by DPREP. They are the Status Word 2 and ephemeris data streams. Dependence of the quality of attitude data on both the quality of the Status Word 2 and ephemeris data streams results in a unique set of platform-specific QA analyses being performed by DPREP.

As mentioned before, two data streams are imbedded within the EMOS-supplied attitude. They are the attitude and Status Word 2 data streams. The attitude data stream contains the attitude of the Aura platform, in quaternions, at a nominal data interval of one second. The Status Word 2 data stream contains the operating mode that the Guidance, Navigation, and Control (GN&C) system was in (i.e. *fine point*) when the attitude of the Aura platform, contained in the attitude data stream, was recorded, at a nominal data interval of eight seconds. DPREP uses the Status

Word 2 data stream to identify the operating mode of the GN&C system for attitude found in the attitude data stream. The mode determines the type and accuracy of the attitude produced by the GN&C system and, subsequently, its usefulness in science data processing. If the mode could not be determined from the Status Word 2 data stream, or if the mode produces attitude of insufficient accuracy, then those attitude data are unusable in science data processing. Thus the quality of Status Word 2 data influences the quality of attitude data and its usefulness.

DPREP transforms the quaternions found in the attitude data stream from the spacecraft reference frame to Euler angles in the instantaneous orbital reference frame. This transformation requires FDD-supplied Toolkit-format ephemeris data of satisfactory quality to be available. Ephemeris data of satisfactory quality consists of those data points that have been, at most, flagged for long gap follows (bit 6), short gap follows (bit 7), short gap precedes (bit 8), long gap precedes (bit 9), repaired data point (bit 10), and/or interpolated data point (bit 11). Ephemeris data points that are flagged for any other data quality condition are considered of poor-quality and will not be used in attitude transformation. If the attitude transformation could not be done because of poor-quality or missing ephemeris data, then those attitude data are unusable in science data processing. Thus the quality of ephemeris data influences the quality of attitude data and its usefulness in science data processing.

As a result, three platform-specific data quality analyses are performed on the EMOS-supplied attitude: the 1) bad status word, 2) missing status word, and 3) bad ephemeris data quality analyses. The bad status word analysis verifies that the GN&C system was in a recognized operating mode. Any unrecognized operating mode in the Status Word 2 data stream results in attitude records being flagged for the bad status word condition (see Table 1-2 for a list of recognized operating modes). The missing status word analysis looks for data gaps in the Status Word 2 timeline and flags those records in the attitude data stream that fall within a Status Word 2 gap for the missing status word condition. Status Word 2 records have a nominal data interval of eight seconds; deviation of the Status Word 2 record interval from the nominal interval identifies Status Word 2 gaps. The bad ephemeris analysis verifies that FDD Toolkit ephemeris data are available and of sufficient quality for the transformation of quaternions to Euler angles. Attitude records falling within intervals of missing or poor-quality ephemeris data get flagged for the bad ephemeris condition.

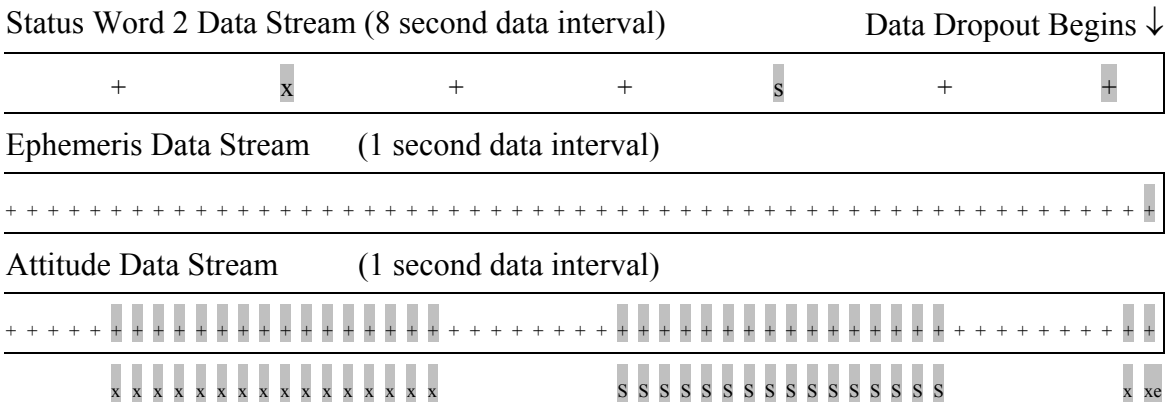

Figure 1-2. Status Word 2 and Ephemeris Influence on Attitude Flagging

Figure 1-2 helps visualize how conditions in the Status Word 2 and ephemeris data streams lead to flagging of attitude in the attitude data stream. The Status Word 2 data stream is at the top, the ephemeris data stream is in the middle, and the attitude data stream is at the bottom. A "+" indicates the presence of a record at that particular time within each data stream. The row below the attitude data stream represents the flagging that occurs on respective records in the attitude data stream, due to conditions in the Status Word 2 and/or ephemeris data streams. Highlighting draws attention to significant events that occur within each data stream.

The highlighted "x" in the Status Word 2 data stream indicates that a Status Word 2 record is missing. All attitude records that temporally fall between the two Status Word 2 records that bound the gap get flagged for the missing status word condition. Attitude records whose timestamps match the timestamps of the Status Word 2 records at either end of the gap do not get flagged.

The highlighted "+" in the Status Word 2 data stream indicates that a Status Word 2 record is not followed by another due to data dropout (or the end of the mission). Consequently, there exist attitude records that are not bounded by two consecutive Status Word 2 records. All attitude records that temporally follow the last Status Word 2 record get flagged for the missing status word condition also. The highlighted "x" below the attitude data stream indicates flagging of the missing status word condition.

The highlighted "s" in the Status Word 2 data stream indicates that that Status Word 2 record has an unrecognized operating mode. In this instance, all attitude records that temporally fall between the two valid Status Word 2 records that bound the bad Status Word 2 record get flagged for the bad status word condition. The highlighted "s" below the attitude data stream indicates flagging of the bad status word condition.

The only anticipated condition that can lead to flagging of the bad ephemeris condition occurs when the last available attitude record temporally follows the last available ephemeris record, prior to an interval of data dropout (or the end of the mission). The highlighted "+" indicates the last ephemeris record in the ephemeris data stream. In this instance, an attitude record temporally follows the last ephemeris record. This attitude record gets flagged for the bad ephemeris word condition. The highlighted "e" below the attitude data stream indicates flagging of the bad ephemeris condition. Only one attitude record is likely be flagged in this circumstance because the nominal data interval for both ephemeris and attitude data is one second. The SDP Toolkit EPH tool, PGS_EPH_EphemAttit, can only return ephemeris data when the timestamp at which ephemeris is required falls on or is bracketed by two ephemeris data points (e.g. PGS_EPH_EphemAttit does not extrapolate ephemeris or attitude data).

Bad status word, missing status word, and bad ephemeris data are unusable in science data processing. Bits 17, 18, and 19 are respectively set in the data quality flag for these conditions. Bit 16, the Platform-Specific Fatal flag, is also set whenever bits 17, 18, and/or 19 are set. The bad status word, missing status word, and bad ephemeris data quality bits apply only to the EMOS-supplied attitude.

Refer to Interface Control Document between the EOS Mission Operations System (EMOS) and the Science Data Processing Segment (SDPS) for the ECS Project, Appendix B (document number 423-21-63, October 2001 draft or later) for more information on the EMOS-supplied attitude granule.

1.2.1.8.1 GN&C Operating Mode Transitions

Because of the similarity between Aura and Aqua attitude processing requirements, Aura attitude processing follows to a great extent the design established by Aqua DPREP. There exist some differences in processing requirements due to Aura's request that attitude be made available whenever science data is present. Not all GN&C operating modes produce attitude of a quality that can be used in geolocation however. Hence it is important for Aura to know what GN&C operating mode and mode transitions occur and when they occur prior to geolocating science data. Aura DPREP supplies this additional information.

The GN&C operating mode indicates the mode the GN&C was in while recording attitude data, and it is the operating mode that determines the suitability of attitude for geolocation. The operating mode is found in the Status Word 2 record and is reported every eight seconds. Table 1-2 describes the values the operating mode can assume and under which modes the Aura science instruments produce data.

Table 1-2. GN&C Operating Mode Description (1 of 2)

Binary	Decimal	GN&C Operating Mode Description	Science Data Possible?
000	0	Mode Zero	No
001	1	Attitude Hold	Yes
010	2	Sun Hold	No

Table 1-2. GN&C Operating Mode Description (2 of 2)

Binary	Decimal	GN&C Operating Mode Description	Science Data Possible?
011	3	Fine Point	Yes
100	4	Earth Point	Yes[2]
101	5	Sun Point	No

Attitude data can transition into and out of science producing modes, and between science producing modes. Table 1-3 outlines the possible transitions between operating modes and the associated mode transition value assigned by DPREP to the transition.

Table 1-3. Operating Mode Transitions and Mode Transition Values

	To	0	1	2	3	4	5
From	**0**	0	7	7	7	7	7
	1	7	0	7	1	2	7
	2	7	7	0	7	7	7
	3	7	3	7	0	4	7
	4	7	5	7	6	0	7
	5	7	7	7	7	7	0

In Table 1-3, the leftmost column is the mode transitioned from, the top row is the mode transitioned to. Value 0 implies that no mode transition occurred. Value 7 implies a transition into or out of a non-science-producing mode. Some of these transitions never occur but they are nevertheless given a transition value. Table 1-4 provides an interpretation of mode transition values.

Table 1-4. Interpretation of Mode Transition Values (1 of 2)

Binary	Decimal	Interpretation
000	0	No transition has occurred between the Status Word 2 records that bracket this attitude.
001	1	A transition from *attitude hold* to *fine point*. The spacecraft is cycling from propulsion mode to normal science mode. Instruments may be able to take data during both these modes.
010	2	A transition from *attitude hold* to *earth point*. The spacecraft is cycling from propulsion mode to either a stand-by mode or a safe mode. It is possible that MLS can take data during *earth point* mode.

[2] MLS may be able to produce science data during earth point mode so it is treated as a science-producing mode in this operation.

Table 1-4. Interpretation of Mode Transition Values (2 of 2)

Binary	Decimal	Interpretation
011	3	A transition from *fine point* to *attitude hold*. The spacecraft is cycling from *fine point* to propulsion for orbit adjustment. Instruments can take data during both these modes.
100	4	A transition from *fine point* to *earth point*. MLS may be able to take data during *earth point* mode.
101	5	A transition from *earth point* to *attitude hold*. This transition is not likely.
110	6	A transition from *earth point* to *fine point*.
111	7	Any transition between, into, or out of non-science data-taking modes. Some of these transitions are not possible, e.g. it is not possible to go from *mode zero* to *fine point* mode. In general, a value of 7 in this field will signal that the data may be unusable if DPREP is able to process it at all.

The binary value of the GN&C operating mode and mode transition are written to the data quality flag in each attitude record generated by Aura DPREP. Bits 20 through 22 contain the operating mode while bits 23 through 25 contain the mode transition value. This information is made available to the Science PGE through the attitude data quality flag returned by the SDP Toolkit EPH tools PGS_EPH_EphemAttit and PGS_EPH_EphAtt_unInterpolate. The Science PGE can thus decide on a course of action for geolocation based on the operating mode and mode transition found in the data quality flag.

Figure 1-3 illustrates how DPREP processes the operating mode and mode transition when the GN&C cycles between modes. S1 through S4 represent Status Word 2 records within a timeline. D1 through D25 represent attitude data records within the same timeline. Assume that the operating mode found in S1 is the same as that found in S2 (S1 = S2). Also assume that S2 ≠ S3, and that S3 = S4. The operating mode therefore transitions between S2 and S3.

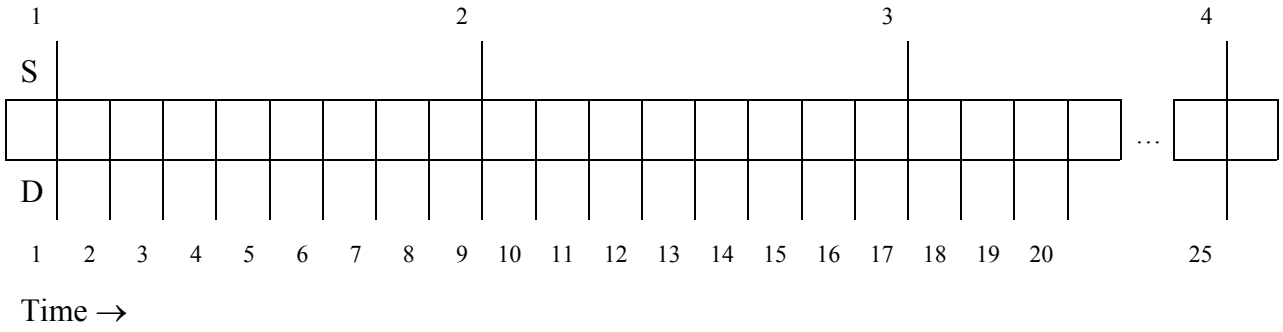

Figure 1-3. Processing of the Operating Mode and Mode Transition by DPREP

Attitude data records D1 through D25 have the following operating modes and mode transitions "flagged" within the data quality flag. D1 through D8 are flagged with operating mode S1 and mode transition 0 (no mode transition occurs between S1 and S2). D9 through D16 are flagged with operating mode S2 (= S1) and mode transition S2-to-S3. D17 through D24 are flagged with the operating mode S3 and mode transition 0 (no mode transition occurs between S3 and S4). D25 is flagged with mode S4 (= S3) and mode transition 0.

All slew maneuvers are expected to occur while in *fine point* mode. The only way to determine if a slew is occurring is to inspect the Euler angles provided by the SDP Toolkit and observe changes. If 0.0012 radians are used as the threshold for detecting the start of a maneuver, then one will know that the spacecraft is proceeding into a maneuver within two seconds of the maneuver start. The spacecraft is expected to maintain pointing to within 0.00012 radians per axis, and transitions into safe mode if any axis exceeds 0.017 radians (0.9 degrees) from its commanded position.

1.2.1.9 Interpretation of Data Quality Flag in Data Processing

The design of the data quality flag permits the recording of detailed QA analysis information, and at the same time allows rapid interpretation of the information contained therein. The data quality flag encompasses a typical long integer (32 bit) word and is divided into three major sections:

1. Overall Summary Bit (Bit 0).
2. Platform-Generic Quality Bits.
3. Platform-Specific Quality Bits.

Figure 1-4 outlines the data quality flag. This map coincides with the Aura data quality flag bit descriptions provided in Table 1-1.

0	Platform-Generic Quality Bits															Platform-Specific Quality Bits															
0	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1

Bit 0 Least Significant Bit 31 Most Significant

Figure 1-4. Ephemeris and Attitude Data Quality Flags

The Overall Summary Bit, bit 0, summaries the contents of the entire flag; bit 0 remains clear if and only if *all* bits within the quality flag remain clear after QA.

The Platform-Generic Quality Bits, bits 1 through 15, summarize the outcome of the QA analyses described in Sections 1.2.1.1 through 1.2.1.7. These analyses encompass the standard set of analyses that all versions of DPREP are encouraged to adopt. For this reason, bits 1 through 15 are called the Platform-Generic Quality Bits. Bit 1, called the Data State Summary Bit, summarizes the outcome of all platform-generic analyses. Bit 1 is set if any of bits 2 through

15 are set. Likewise, if the Data State Summary Bit is set, then the Overall Summary Bit is set also.

The Platform-Specific Quality Bits summarize the outcome of QA analyses specific to the platform in question. Section 1.2.1.8 describes quality analyses specific to the Aura platform. Bit 16, the Platform-Specific Summary Bit, summarizes the outcome of platform-specific analyses and is set if any of bits 17 through 31 are set.

Just because a bit had been set within the data quality flag, it does not mean that a fatal QA condition had been encountered. For example, the two records that bound a long data gap are flagged for "long gap follows" and "long gap precedes", respectively. These records are still considered useful. Furthermore, the summary bits do not indicate that a fatal condition has been encountered. The summary bit simply indicates that a bit has been set within the section of the data quality flag governed by the summary bit. Summary bits are intended for quick-look purposes only, and indicate that examination of the respective section's quality bits is warranted.

Bits 12 through 15 are reserved for use by the SDP Toolkit; of these, bits 12 and 14 are currently used. Bit 12 indicates that PGS_EPH_EphemAttit was unable to derive ephemeris or attitude data at the requested timestamp. Conditions under which bit 12 can be set are many; examples include failure to read the Toolkit ephemeris and attitude granules or failure to interpolate data at the requested timestamp. Whenever the timestamp for which ephemeris and attitude are requested does not coincide with an existent timestamp in the ephemeris or attitude timeline, PGS_EPH_EphemAttit interpolates to the requested timestamp. PGS_EPH_EphemAttit can successfully interpolate across gaps up to 60 seconds in duration. Bit 14 is set to indicate that the data have been successfully interpolated. PGS_EPH_EphemAttit cannot interpolate across gaps longer than 60 seconds, and returns a warning whenever asked to do so. The interpolated ephemeris and attitude values are set to error values (e.g. PGSd_GEO_ERROR_VALUE, currently set to 1.0E+50) that indicate the interpolation could not be done, and bit 12 is set as well. It is left to the Science PGE to decide the course of action whenever this happens. Contrary to DPREP QA analysis standards, the Toolkit does not set the Data State Summary Bit or the Overall Summary Bit when it sets bits 12 and/or 14.

For some platforms (i.e. Terra), DPREP repairs ephemeris data. The interpolation used to repair the ephemeris data stream differs from that performed by the SDP Toolkit, with respect to methodology and intent. Data repair restores useful data to the ephemeris data stream at the nominal data interval only (i.e. 1.024 seconds for Terra). Science data processing requires (more often than not) ephemeris and attitude data at times that are not represented in ephemeris or attitude timelines. PGS_EPH_EphemAttit interpolation provides ephemeris and attitude data at inter-record times. Data quality flag bits 10 and 14 are used to distinguish these data. Bit 10 indicates that repair has been performed on the nominal timeline; bit 14 indicates that PGS_EPH_EphemAttit interpolated to an inter-record time. When the Toolkit interpolates, it performs a logical "or" on the quality flags on either side of the interpolated point to derive its quality flag. Bit 10 is never set in Aura data because Aura DPREP does not repair the ephemeris or attitude data streams.

Bits 2, 5, 12, 16, 17, 18, and 19 signal conditions that Aura science data processing should consider fatal. It is strongly recommended that data processing not use ephemeris or attitude records flagged for these conditions.

PGS_EPH_ManageMasks provides the means for managing the masks by which ephemeris and attitude are selected by data quality. See Section 4 for additional information.

1.2.1.10 QA Summary Metadata

QA summary metadata summarize the quality of ephemeris and attitude data processed by DPREP. This metadata can be found in the Toolkit and HDF-format granule header and within metadata that is archived in the Science Data Server along with the DPREP data products. All versions of DPREP (regardless of platform) document three QA summaries: 1) percent-interpolated data, 2) percent-missing data, and finally 3) percent-out-of-bounds data. The percent-interpolated QA summary metadata documents the percentage of records repaired in a granule. The percent-missing QA summary metadata documents the percentage of records missing from a granule. The percent-out-of-bounds QA summary metadata documents the percentage of records that were flagged for a limit or range violation in a granule. Of these, Aura DPREP computes only the percent-missing and percent-out-of-bounds QA summary metadata. The percent-interpolated QA summary metadata is not computed because Aura DPREP does not perform data repair.

The percent-missing data gets set to one-percent or more in the processing of FDD-supplied ephemeris or EMOS-supplied attitude data whenever a long data gap is encountered. A long gap is a gap of 1 or more ephemeris or attitude records. Similarly, the percent-out-of-bounds data gets set to one-percent or more whenever a range violation is encountered in the ephemeris or attitude data streams.

The QA summary metadata has three main uses. First of all, this metadata allows Science PGEs to make rapid decisions regarding the acceptability of ephemeris and attitude for science data processing (i.e. a Science PGE can be selected to run only if the percent-missing ephemeris data are below a specified threshold). Secondly, DPREP can have a subscription for replacement FDD ephemeris or EMOS attitude data placed based on QA summary results (i.e. DPREP places a subscription for replacement FDD ephemeris data whenever a long data gap spans one-percent or more of the FDD-supplied ephemeris granule). Finally, Science PGE processing can be made to wait for replacement ephemeris or attitude by setting the percent-missing data threshold to one-percent or less on the ephemeris data (ESDT AUREPHMN) and one-percent or less on the attitude data (ESDT AURATTN).

Aura attitude processing generates three additional QA summary metadata: 1) percent-bad-status-word data, 2) percent-missing-status-word data, and 3) percent-bad-ephemeris data. These QA summary metadata are archived in the Science Data Server and, consequently, can be utilized like the QA summary metadata described above (i.e. in placing a subscription for attitude data replacement). They are also stored in the attitude product granule headers along with the previously described QA summary metadata. The percent-bad-status-word QA summary metadata documents the percentage of attitude records that were flagged because the GN&C system was in an unrecognized operating mode. The percent-missing-status-word QA

summary metadata documents the percentage of attitude records that were flagged because the mode of the GN&C system could not be determined due to missing Status Word 2 records. The percent-bad-ephemeris QA summary metadata documents the percentage of attitude records that were flagged because of the unsatisfactory quality of ephemeris data available to attitude processing. Refer to Section 1.2.1.8 for a description of the bad status word, missing status word, and bad ephemeris Aura platform-specific QA analyses.

DPREP also sets a granule level QA flag, the automatic QA flag, in the metadata generated by DPREP. This flag receives a value of either "Passed" or "Failed" along with an explanation of the failure reason. Any DPREP-generated ephemeris granule that has a long data gap or a range violation has the automatic QA flag set to "Failed". Any DPREP-generated attitude granule that has a range violation has the automatic QA flag set to "Failed".

1.2.2 Aura Data Replacement

DPREP performs data quality analyses on all of the ephemeris and attitude data streams that DPREP processes. If DPREP finds too many problems with a data stream, DPREP requests replacement data from FDD or EMOS by way of the Spatial Subscription Server. The conditions under which DPREP makes a replacement request depends on the data stream being processed. DPREP is most discriminating when assessing the quality of the FDD ephemeris data stream. The FDD-supplied ephemeris data stream has been extensively preprocessed and is, therefore, expected to be error free. Any problem encountered results in a request for replacement from FDD. Consequently, DPREP requests replacement of the FDD-supplied ephemeris data whenever any of the data quality analyses indicates a problem. Conversely, DPREP is least discriminating when assessing the quality of the EMOS attitude data stream. The EMOS-supplied attitude has had a lesser amount of preprocessing performed and is not expected to be completely error free. Consequently, DPREP requests replacement of the EMOS-supplied attitude data whenever any of the data quality analyses indicates a problem, with the exception of data gap analysis. Data gaps are expected in the EMOS-supplied attitude data stream. Neither EMOS nor DPREP repairs gaps. Section 5.3 describes the data replacement operational scenario.

Whenever a gap bridges granule boundaries in the FDD-supplied ephemeris and EMOS-supplied attitude timelines, the gap is filled by the piecemeal replacement of two granules: the granule in which the gap begins and the granule in which the gap ends.

1.3 DPREP Data Products

Standard DPREP processing produces two ephemeris and attitude product data streams: 1) the FDD-supplied Toolkit ephemeris data stream (ESDT short names AUREPHMN and AUREPHMH) and 2) the EMOS-supplied Toolkit attitude data stream (AURATTN and AURATTH). The short name that ends with a penultimate “H” stands for HDF format while “N” stands for native (or Toolkit) format.

For the discussion that follows, the reader is referred to EOSDIS Spacecraft Ephemeris and Attitude Data Specification: Contents and Structure for details regarding the contents of Toolkit-format ephemeris and attitude granules and the metadata contained therein. This document can be found on the World Wide Web at http://newsroom.gsfc.nasa.gov/sdptoolkit/appendl.html and

is summarized in the Release 6A.07 SDP Toolkit User's Guide for the ECS Project, Appendix L (document number 333-CD-605-003, April 2003 draft and later). HDF documentation can be found on the World Wide Web at http://hdf.ncsa.uiuc.edu/.

1.3.1 Granule Format

The basic structure is the same for the Toolkit and HDF-format ephemeris granules:

Header Record
Universal Reference Records
Data Records
Orbit Metadata Records

An ephemeris granule consists of a single header record followed by three multi-record sections that contain the universal references (URs), the ephemeris data, and the orbit metadata. The number of records in each multi-record section can be found in the header record. Header fields *nURs*, *nRecords*, and *nOrbits* specify the number of records found in each section, respectively.

An attitude granule consists of only the first three sections shown above. The formats of records found in the each section differ between the attitude and ephemeris granules, of course, but the record lengths remain the same.

As for the HDF-format ephemeris and attitude granules, each section is written as a single Vdata table using standard HDF (except for the header and universal reference sections, which have been combined into a single Vdata table). Vdata table field names are the same as those found in the record structures provided by the SDP Toolkit for the Toolkit-format granules. Spare fields used to pad the Toolkit record structures to fixed lengths are not included in the Vdata tables, however.

1.3.2 Granule Header

SDP Toolkit and DPREP design require that each version of DPREP provide a standard set of metadata within the header of the Toolkit and HDF-format ephemeris and attitude granules. This metadata is considered common to all versions of DPREP (regardless of platform) and must therefore be supplied in the standard Toolkit format.

Each platform also has the option of adding platform-specific metadata to the ephemeris and attitude granule headers as required by the design of DPREP for that platform. Space for the platform-specific metadata is taken from spares that pad the Toolkit-format granule header out to 512 bytes. Any platform-specific metadata can be added to the header as long as the platform-generic header metadata as well as the length of the header (e.g. 512 bytes) are preserved.

1.3.3 Universal References

SDP Toolkit and DPREP design are also driven by project requirements. All versions of DPREP are required to save the universal reference of all inputs used in deriving a DPREP data product

within the product itself. The list of universal references follows the header in each Toolkit and HDF-format ephemeris and attitude granule, the number of which can be found in the granule header.

1.3.4 Orbit Metadata

1.3.4.1 Orbit Metadata Records

Orbit metadata include the following items that are generated for each orbit encountered in the Aura ephemeris data stream:

1. True-of-Date (TOD) Orbit number.
2. Descending TOD node crossing time in TAI93.
3. Terrestrial longitude at the descending node crossing, in radians.
4. Ascending TOD node crossing time in TAI93; this metatdata is recorded in the ephemeris data products but not in the inventory metadata.

Every ephemeris granule produced by DPREP is tagged with one orbit metadata record for each orbit "touched" in the time interval spanned by that granule. Orbit metadata records follow the ephemeris data in the Toolkit and HDF-format ephemeris granules. For Aura, a standard 24-hour ephemeris granule may be tagged with either 15 or 16 orbit metadata records depending on how the orbits are encountered. Orbit metadata get archived along with other DPREP metadata.

Orbit metadata are calculated from the ascending and descending node crossings that are encountered in the FDD-supplied ephemeris data stream. Position vectors are rotated from Mean-of-J2000 to True-of-Date prior to detecting node crossings and computing the orbit metadata.

For DPREP an orbit goes from one TOD ascending node to the next (FDS orbits work the same, but in Mean-of-J2000). Counting out ascending node crossings from the beginning of the mission generates orbit numbers. An initial orbit number must be supplied whenever the boot-up procedure (Profile 2) of DPREP PGEs EcDpPrAuraEphemerisDPREP_PGE is used. S4PM prompts for an initial orbit number when the bootstrap procedure is invoked (see Section 5.2 for details). DPREP counts orbits from the initial value supplied by PCF logical ID 998. For consistency with FDD procedure, the first (partial) orbit after launch is orbit 0.

Nominal DPREP processing (Profile 1) resumes orbit counting at the last orbit that had been encountered in the ephemeris data stream. DPREP resumes counting at the orbit number found in the last orbit metadata record of the preceding Toolkit-format ephemeris granule. Profile 1 processing depends on a preceding granule in order to determine where orbit counting is to resume. Profile 1 does not require the immediately preceding granule to be available, however. DPREP accepts the most recent granule, up to as much as seven days in the past. If the preceding granule does not immediately precede the processing interval, DPREP calculates the number of orbits that have elapsed from the last known orbit to decide on where to resume counting.

Ascending and descending node-crossing times are determined by first detecting when the Z component of the position vector changes sign. Whenever Z changes sign from minus to plus,

Aura crosses the ascending node. Whenever Z changes from plus to minus, Aura crosses the descending node. Linearly interpolating the times bracketing a node crossing to when Z is zero determines the node crossing time. The descending longitude is the difference between the right ascension of Aura and the Greenwich apparent sidereal time. Refer to Generation of Orbit Number and Equator Crossing Time and Longitude for EOSDIS (P. Noerdlinger, SAC, November 12, 1995) for more information on generating orbit metadata. This document can be found on the World Wide Web at http://newsroom.gsfc.nasa.gov/sdptoolkit/orbitgen.html.

In order to generate orbit metadata for node crossings missing from the ephemeris data stream, DPREP first determines the orbital period of Aura from two successive ascending or descending node crossings found in the data segment being processed. The orbital period is used to "project" node-crossing times for ascending and descending node crossings not detected in the ephemeris data stream. The orbital period is also used to "project" descending node longitudes for missing descending node crossings.

Figure 1-5 aids in the visualization of how orbits may fall within the 24-hour FDD ephemeris granules. This figure is not intended in any way to reflect actual events but to merely aid visualization. Orbits go from successive TOD ascending nodes crossings, A, with an intervening descending node, D. A new orbit starts at each ascending node; the incremented orbit number reflects this. With one Aura orbital period expected to last approximately 99 minutes, either 15 or 16 orbits can span the 24-hour granules. For example, 16 orbits span the Day 7 granule (orbits 103 through 118) while 15 orbits span the Day 8 granule (orbits 118 through 132). Because an orbit often touches neighboring granules, neighboring granules are tagged with the duplicate orbit metadata.

The ascending node crossing time of the first orbit and the descending node crossing time of the last orbit that span a granule do not always bracket the start and end times of the granule. For example, the first ascending node and last descending node crossing time do bracket the Day 7 granule (orbits 103 through 118 inclusive), but do not bracket the Day 8 granule (orbits 118 through 132). The last descending node crossing time for the Day 8 granule occurs well before the end of the granule. DPREP does not always provide orbit metadata that *temporally* bracket the granule interval.

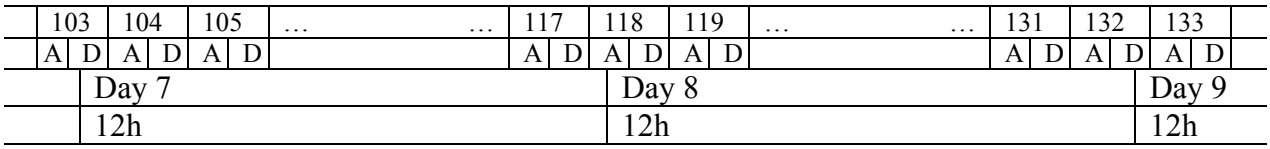

Figure 1-5. Orbit - Granule Timelines

1.3.4.2 Orbital Elements

Included in the orbit metadata are the orbital elements of the Aura platform. The orbital elements can be found, along with the epoch to which they pertain, in the header record of the Toolkit and HDF-format ephemeris granules, as well as the inventory metadata (Aura DPREP only).

The FDD provides orbital elements and the epoch to which they pertain in the FDD-supplied ephemeris granules. Consequently, DPREP does not calculate orbital elements when processing the FDD-supplied ephemeris granules. The FDD-supplied orbital elements are defined in the Mean-of-J2000 ECI frame.

1.3.5 Metadata Files

For each Toolkit and HDF-format ephemeris and attitude granule produced by DPREP, DPREP generates an accompanying metadata file. The Science Data Server (SDSRV) requires metadata to be provided along with the granule being archived in order for archiving to be completed successfully. In general, this metadata is ESDT-specific and is provided to the SDSRV via the metadata file. The metadata that are documented in Table 1-5 describe all Aura DPREP generated ESDTs: AUREPHMN, AUREPHMH, AURATTN, and AURATTH.

The metadata, once archived, become searchable. S4PM uses the time range of DPREP products in scheduling their use by Science PGEs. Furthermore, qualified subscriptions can be placed on the archived metadata, as is done when placing a subscription on the QAPercentMissingData metadata to achieve replacement of FDD-supplied ephemeris data (Section 5.3).

More information about metadata can be found in Release B Science Data Processing Segment (SDPS) Database Design and Database Schema Specifications for the ECS Project (document number 311-CD-008-001).

Table 1-5. DPREP Metadata (1 of 3)

Metadata Name	Set By[3]	Description
AuraEccentricity	PGE	The eccentricity of the Aura spacecraft orbit.
AuraInclination	PGE	The inclination of the Aura spacecraft orbit in radians.
AuraKeplerEpochDate	PGE	Epoch date of the Aura orbital elements in ASCII.
AuraKeplerEpochTime	PGE	Epoch time of the Aura orbital elements in ASCII.
AuraMeanAnomaly	PGE	The mean anomaly at epoch in radians.
AuraPerigee	PGE	The argument of the perigee in radians.
AuraRightAscension	PGE	The right ascension of the ascending node in radians.
AuraSemiMajorAxis	PGE	Semi-major axis of the Aura spacecraft orbit in meters.

[3] DP stands for Data Producer which means instrument team, PI or other qualified person. PGE stands for Product Generation Executive, the science software that produces most of the granule level metadata. PLS stands for Planning Subsystem that provides plans and reports to the database. DPS stands for Data Processing Subsystem that supports the operation, integration, and test of science software. DSS stands for Data Server Subsystem that provides database pointers or references to archived data objects. DAAC stands for Distributed Active Archive Center where operations staff assists the DP in the population process.

AutomaticQualityFlag	PGE	The granule level flag set by the PGE to access the quality of the granule produced by the PGE.
AutomaticQualityFlagExplanation	PGE	Text explaining the Automatic Quality Flag.
EquatorCrossingDate	PGE	The date of the descending equator crossing.

Table 1-5. DPREP Metadata (2 of 3)

Metadata Name	Set By	Description
EquatorCrossingLongitude	PGE	The terrestrial longitude under the descending equator crossing.
EquatorCrossingTime	PGE	The time of the descending equator crossing.
InputPointer	PGE	The logical reference to a data granule.
LocalGranuleID	PGE	Unique product identifier for locally produced granules.
LocalVersionID	PGE	Unique product version identifier for locally produced granules whose use is defined by the science data provider; currently unused by DPREP.
OperationalQualityFlag	PGE	The granule level flag set by the DAAC QA process to access the operational quality of the granule.
OperationalQualityFlagExplanation	PGE	Text explaining the contents of the Automatic Quality Flag.
OrbitalModelName	PGE	The orbital model to used in determining the platform geo-location.
OrbitNumber	PGE	The orbit number to which the data pertain.
ParameterName	PGE	Used to name characteristics of the granule which have not been included in the core set of metadata attributes.
ProductionDateTime	TK	Date and time when the granule was generated.
QAPercentBadEphemerisData	PGE	Percentage of attitude records that are bad ephemeris data flagged in granule (attitude granules only).
QAPercentBadStatusWords	PGE	Percentage of attitude records that are bad Status Word 2 flagged in granule (attitude granules only).
QAPercentInterpolatedData	PGE	Percentage of records generated via data repair in granule.
QAPercentMissingData	PGE	Percentage of records that are missing from granule.
QAPercentMissingStatusWords	PGE	Percentage of records that are missing Status Word 2 flagged in granule (attitude granules only).
QAPercentOutofBoundsData	PGE	Percentage of records that are limit and/or range flagged in granule.
RangeBeginningDate	PGE	The year, month, and day when the temporal coverage period being described began.
RangeBeginningTime	PGE	The hour, minutes, and seconds of the temporal coverage period being described began.
RangeEndingDate	PGE	The year, month, and day when the temporal coverage period being described ended.
RangeEndingTime	PGE	The hour, minutes, and seconds of the temporal coverage period being described ended.
ReprocessingActual	MCF	States what reprocessing has been performed on this granule.
ReprocessingPlanned	MCF	States what reprocessing may be performed on this granule.
ScienceQualityFlag	DP	The granule level flag set by the Science Team QA process to access the scientific quality of the granule.
ScienceQualityFlagExplanation	DP	Text explaining the contents of the Science Quality Flag.

Table 1-5. DPREP Metadata (3 of 3)

Metadata Name	Set By	Description
ShortName	MCF	The ECS Technical Baseline product names used in identifying the contents of the granule.
SizeMBECSDataGranule	DSS	The volume of data contained in the granule. (Megabytes).
StartOrbitNumber	PGE	The orbit number at the start of the granule.
StopOrbitNumber	PGE	The orbit number at the end of the granule.
VersionID	MCF	Version identifier of the granule.

1.3.6 Local Granule ID Format

DPREP generates a local granule ID for each granule it produces according to the naming convention described here. The local granule ID can be found in the metadata associated with each DPREP product, and it is this name that granules are given in distribution.

The DPREP-generated local granule ID has the format

ESDT.PlatformCodeYYYYDDD.HHMM.Version.YYYYDDDHHMMSS.Extension

where

ESDT	The ESDT to which the granule pertains (i.e. AUREPHMN).
PlatformCode	A single-character code pertaining to the platform with which the data are associated (i.e. C for Aura).
YYYYDDD	The year and day-of-year to which the data pertain.
HHMM	The hour and minute of the start time of the data segment to which the data pertain.
Version	The version number of the ESDT to which the granule pertains.
YYYYDDDHHMMSS	The time at which the data were produced.
Extension	The file extension that denotes the internal format of the data, hdf for HDF-format data or NULL for Toolkit-format data.

Because of the substantial impact on users of DPREP data products, it is highly unlikely that the format of the local granule ID will ever change from that described above.

1.4 DPREP Processing Scenario

DPREP processing is granule-oriented; the processing interval selects data granules from the archive for DPREP to process, which then get processed to completion. Ephemeris data that are processed by DPREP arrive in 24-hour segments while attitude data processed by DPREP arrive

in two-hour segments. Therefore, ephemeris-processing intervals must be selected in multiples of days while attitude-processing intervals must be selected in multiples of two hours. Figure 1-6 diagrams DPREP ephemeris processing while Figure 1-7 diagrams DPREP attitude processing.

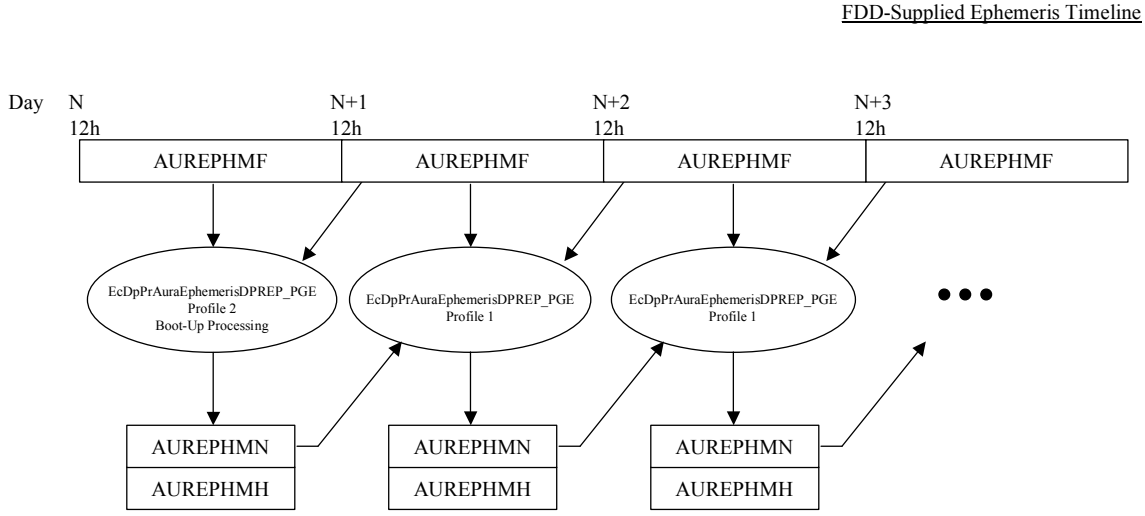

Figure 1-6. Aura DPREP Standard Ephemeris Processing Scenario

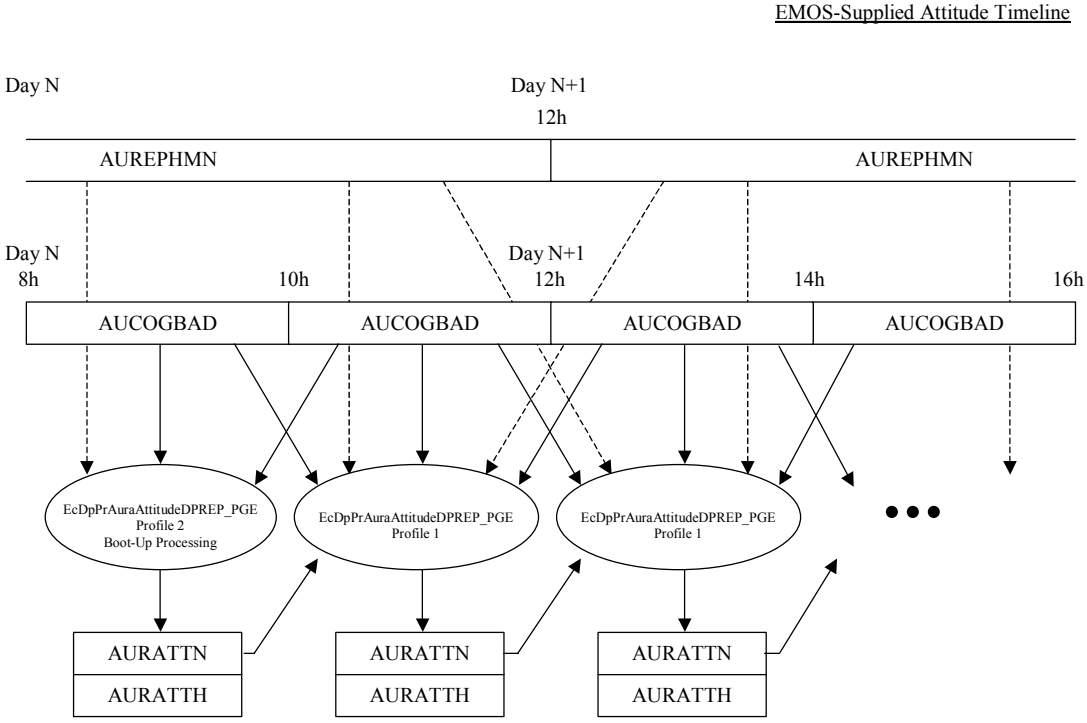

Figure 1-7. Aura DPREP Standard Attitude Processing Scenario

Standard processing produces one ephemeris and one attitude product data stream: 1) the FDD-supplied Toolkit ephemeris data stream and 2) the EMOS-supplied Toolkit attitude data stream.

Processing of the ephemeris and attitude data streams occurs daily. Because FDD ephemeris is required in the processing of EMOS attitude, the processing of ephemeris occurs prior to the processing of attitude. Because the 24-hour FDD ephemeris data segment extends from noon-to-noon, the processing day for Aura attitude and science data likewise extends from noon-to-noon.

EMOS attitude processing requires FDD ephemeris in order to transform quaternions into Euler angles. In order to process attitude at the Aura processing day boundary, ephemeris from both days on either side of the boundary must be available. Consequently, the processing of the 10 to 12 hour attitude segment is delayed until ephemeris from the day N+1 segment becomes available. Processing of the 10 to 12 hour segment may be delayed as much as 24 hours.

EMOS attitude processing requires raw input from the preceding segment in order to complete continuity checks between the preceding and current data segments on the Status Word 2 data stream that is imbedded within the EMOS-supplied attitude granules. Raw input is also required from the following data segment in order to complete continuity checks between the current and following data segments on the attitude data stream as well as the Status Word 2 data stream. See Section 1.2.1.8 for more on the processing of the attitude and Status Word 2 data streams.

Because DPREP's data quality analysis includes checks for continuity across granule boundaries, EMOS attitude processing must lag at least two hours behind "real-time" (due to exceptional Aura DPREP processing requirements, this lag is usually much longer; see Section 1.4.2). DPREP expects the EMOS-supplied attitude granule that follows the segment being processed to be available for continuity checking. Hence the processing lag.

The net result of DPREP processing, by way of continuing the examples used above, is outlined in ***Figure 1-8***.

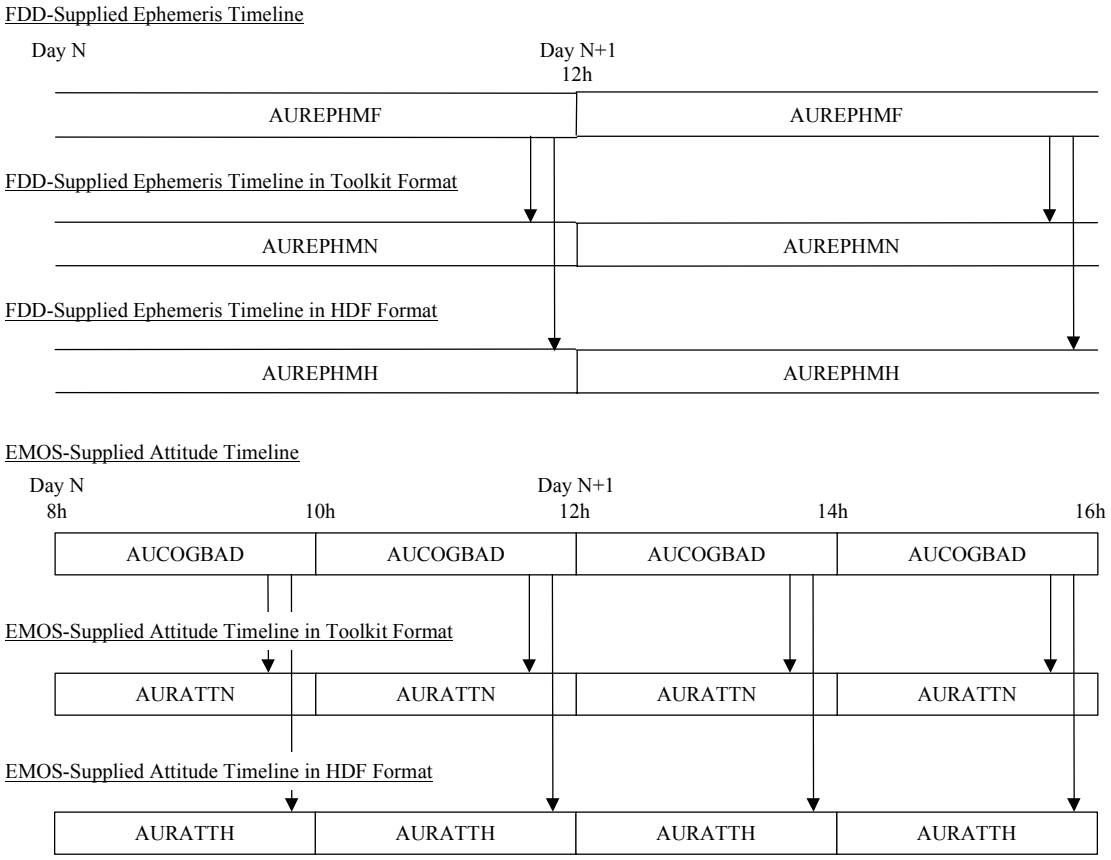

Figure 1-8. Aura Ephemeris and Attitude Timelines

1.4.1 DPREP PGE Profiles

Processing of the FDD ephemeris and the EMOS attitude data streams must be initialized with a boot-up process that runs on the first mission granule (or the first granule that follows data dropout). Profile 2 of PGE EcDpPrAuraEphemerisDPREP_PGE performs the boot-up of FDD ephemeris processing. Similarly, Profile 2 of PGE EcDpPrAuraAttitudeDPREP_PGE performs boot-up of EMOS attitude processing. Profile 1 assumes processing thereafter, in both the FDD ephemeris and the EMOS attitude data streams. Because attitude processing depends upon the availability of Toolkit-format ephemeris data (produced by DPREP from FDD-supplied ephemeris data), processing of the FDD-supplied ephemeris data occurs prior to the processing of EMOS-supplied attitude data.

Because FDD-supplied ephemeris processing begins after several orbits have elapsed at the very beginning of the mission, the initial orbit number must be requested from the Flight Operations Team (FOT) and supplied to DPREP prior to scheduling Profile 2 processing. The FOT must be asked to supply a re-starting orbit number when booting-up after data dropout. See Section 0 for details.

In order for DPREP to successfully perform QA analysis, DPREP depends on DPREP output produced from processing the segment immediately preceding the segment being processed. Likewise, DPREP processing depends on the availability of the raw input granule that follows the one being processed. Therefore, FDD ephemeris data processing requires the preceding segment's Toolkit-format ephemeris granules, as well as the following segment's FDD-supplied ephemeris granule. By the same token, EMOS attitude data processing requires the preceding segment's Toolkit-format attitude granule, as well as the following segment's EMOS-supplied attitude granule. This arrangement is typical of Profile 1 processing. Profile 2 processing does not depend on DPREP output from the preceding segment (a preceding granule would not exist in the situation that Profile 2 is intended to run).

"Day N", as depicted in Figure 1-6 and Figure 1-7, indicates the beginning of mission or the resumption of processing following an interval of data dropout. Profile 2 processes the first ephemeris and attitude segments: the segment that spans days N to N+1 in the ephemeris-processing example and the segment that spans hours 8 to 10 in the attitude-processing example. Profile 1 assumes processing responsibility from day N+1 through the end of the mission (or the next data dropout) in the ephemeris-processing example and from 10 hours of day N through the end of the mission (or the next data dropout) in the attitude-processing example.

In addition to Profiles 1 and 2, DPREP recognizes Profiles 3 and 4. Profile 3 terminates DPREP processing prior to the end of the mission or an interval of data dropout. Unlike Profiles 1 and 2, Profile 3 does not depend on the following segment. Profile 4 processes isolated segments. Therefore, Profile 4 does not depend on the preceding or following segments.

1.4.2 Current DPREP Production Rules

Even though Profile 1 processing of FDD-supplied ephemeris data depends on a preceding granule being available, Profile 1 does not require the granule to be supplied by the segment that *immediately* precedes the segment being processed. S4PM begins by looking at the segment that immediately precedes the segment being processed. If the granule is available, processing

begins. If it is not available, S4PM waits up to one hour for the granule to appear. If it appears during that hour, processing starts immediately. If at the end of one hour the granule from the immediately preceding segment is still not available, the wait period expires. S4PM then looks up to seven days into the past for the most recently available granule. If no preceding segment's granule is available from the past seven days, S4PM halts DPREP processing. Profile 2 boot-up processing must then be arranged in order for processing to proceed (see Section 5.2 for information on initiating Profile 2 DPREP processing). These production rules could change in order to keep pace with processing demands.

Profile 1 processing of EMOS-supplied attitude data depends on, but does not require, the availability of a preceding granule. Instead of looking up to seven days into the past for a preceding granule, processing waits up to *36 hours* for the immediately preceding granule to arrive. If this timer should expire without the preceding granule becoming available, Profile 1 processing reverts to Profile 2 processing (Profile 2 does not depend on output from a preceding data segment). Processing therefore proceeds without the immediately preceding granule if the 36-hour timer expires prior to its arrival. The need for FDD-supplied ephemeris in Aura attitude processing imposes this lengthy wait for the preceding granule. The overriding factor in attitude processing is ephemeris availability. Therefore the timer on the preceding attitude granule must match or exceed the timer on ephemeris granules.

Similarly, Profile 1 processing depends on, but does not require, the raw input granule from the segment that immediately follows the segment being processed. If the FDD-supplied ephemeris granule does not become available after a ten-minute wait period, DPREP reverts to Profile 3 processing (Profile 3 does not depend on the raw input granule from the segment that follows). The wait period is only ten minutes because, in forward processing, the FDD-supplied ephemeris granule will not arrive for at least 24 hours. So that forward processing is not delayed 24 hours, DPREP processing proceeds without the granule after a ten-minute wait. On the other hand, in data reprocessing, the granule is likely to be available but must be retrieved from the archive; ten minutes should be more than adequate for its retrieval. Also, if the EMOS-supplied attitude granule does not become available after a 36-hour wait period, DPREP reverts to Profile 3 processing. The 36-hour wait period seems unnecessarily long but EMOS-supplied attitude typically arrives 24 or more hours in advance of FDD-supplied ephemeris for the same data interval. Unlike the processing scenario outlined above for preceding granules, S4PM never halts DPREP processing if the following granule does not become available.

Profile 1 behaves in this manner so that DPREP processing can proceed with minimal operator intervention if input granules do not arrive in time-order or if some granules do not arrive at all. Given the processing flexibility of Profile 1, neither the scheduling of Profile 3 nor the scheduling of Profile 4 is envisioned operationally.

1.4.3 Non-Time-Ordered DPREP Processing

For the following reasons, it is advantageous to process DPREP in time-order. DPREP uses granules from the *immediately* preceding segment to

1. Initialize the data quality analysis of the current segment.
2. Consistency check data across granule boundaries.

3. Determine where to resume orbit counting when processing orbit metadata.

If time-ordered processing is not possible, DPREP readily accepts FDD ephemeris granules from the most recently available preceding segment, up to seven days in the past. If the preceding granule does not immediately precede the processing interval, DPREP calculates the number of orbits that have elapsed from the last known orbit to decide on where to resume counting. Data quality analyses are re-initialized also when the immediately preceding granule is unavailable.

Because DPREP can process granules that are not in time-order, non-existent long gaps might be accidentally flagged in the ephemeris timeline. A long gap can be flagged between the current and preceding segments if the preceding segment does not *immediately* precede the current. If the gap is filled by a subsequent granule delivery, a long gap is erroneously flagged.

Similarly, DPREP can fail to flag data gaps in the attitude timeline if processing does not occur in time-order. If data from the following segment is not immediately available, DPREP processing continues without input from the following segment. Consequently, gap checking between the current and following segments is not performed. A gap that follows the current processing segment will go undetected.

2. FDD Ephemeris Preprocessing

PGE EcDpPrAuraEphemerisDPREP_PGE preprocesses the FDD-supplied Ephemeris data stream to produce the FDD-supplied Toolkit ephemeris data stream. Two granules are produced from each FDD ephemeris granule that is processed: the Toolkit and HDF-format FDD ephemeris granules. Figure 2-1 highlights the flow of data during FDD ephemeris data processing.

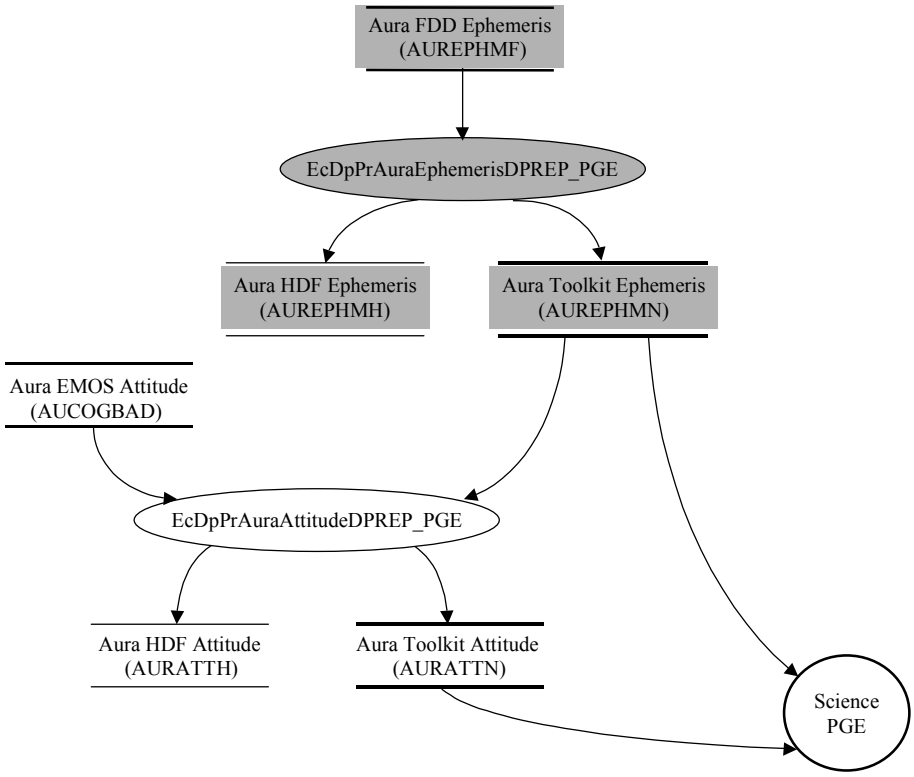

Figure 2-1. Aura DPREP FDD Ephemeris Processing Data Flow

Because of the preprocessing that is performed by FDD on ephemeris data, DPREP performs minimal data quality checking. The data quality analyses include continuity, consistency, range, and data gap checking which are intended mainly to catch transmission errors. DPREP does not perform limit (spike) checking or data repair on FDD ephemeris. In addition to the standard

consistency checks described in Section 1.2.1.1, ephemeris processing requires a match between the expected satellite ID (1234567 for Aura) and the satellite ID found in the FDD ephemeris granule header. The expected satellite ID is retrieved from the PCF as a run-time parameter. Range checking confirms that the magnitude of the position and velocity vectors fall within the permissible range: the geocentric distance can range from 6,500,000 to 7,380,000 meters while the velocity can range from 6,850 to 8,300 meters per second. Data gaps greater than one second (one record or more) are flagged as long gaps. Consequently, all data gaps are flagged as long gaps. Any failure of data quality analysis results in entering a subscription for a replacement granule from FDD. The replacement granule is in the same format as the original FDD ephemeris granule and requires no special preprocessing by DPREP. Refer to Section 1.2.1 for a discussion of the data quality analyses performed by DPREP.

This PGE signals three exit conditions: success, failure, and data replacement required. Status code 0 indicates successful completion. Status code 200 indicates that a fatal error occurred. All downstream processing (i.e. Science PGEs) halts. Status code 216 indicates that replacement data must be requested from FDD. Processing continues in this instance.

Table 2-1 describes the run-time parameters used in processing the FDD ephemeris data. The table indicates the default value associated with the logical ID and which DPREP Profile uses the logical ID. Many of these run-time parameters control the data quality analyses performed on the FDD ephemeris data stream.

Table 2-1. Aura DPREP FDD Ephemeris Processing PCF Logical Ids (1 of 2)

PCF Logical ID	Description	Default	Profile ID			
			1	2	3	4
950	Spacecraft name.	EOSAURA	Y	Y	Y	Y
955	Platform indicator.	C	Y	Y	Y	Y
970	Logical ID of the preceding ephemeris granule (1700 - 1706).	None	Y	N	Y	N
990	PGE version number.	None	Y	Y	Y	Y
998	Initial orbit number.	-1	N	Y	N	Y
999	Profile ID.	None	Y	Y	Y	Y
1000	FDD ephemeris granule to be processed.	None	Y	Y	Y	Y
1020	FDD–supplied ephemeris granule following the granule being processed.	None	Y	Y	N	N
1100	Toolkit-format ephemeris granule file name.	None	Y	Y	Y	Y
1101	HDF-format ephemeris granule file name.	None	Y	Y	Y	Y
1200	FDD Satellite ID.	1234567	Y	Y	Y	Y
1202	Process the entire FDD ephemeris granule regardless of the length of interval spanned by the granule (0) or process the first 24 hours (1). For Aura, the FDD ephemeris granule always spans 24 hours.	0	Y	Y	Y	Y

Table 2-1. Aura DPREP FDD Ephemeris Processing PCF Logical Ids (2 of 2)

PCF Logical ID	Description	Default	Profile ID			
			1	2	3	4
1256	Toolkit-format ephemeris metadata ID.	1100:1	Y	Y	Y	Y
1700 - 1706	Toolkit-format ephemeris granule from a data segment preceding the one being processed, up to 7 days in the past.	None	Y	N	Y	N
5008	Minimum number of consecutive missing data records required for a long ephemeris data gap.	1	Y	Y	Y	Y
5030	Maximum distance from ECI center in meters.	7380000	Y	Y	Y	Y
5031	Minimum distance from ECI center in meters.	6500000	Y	Y	Y	Y
5032	Maximum velocity about ECI center in meters per second.	8300	Y	Y	Y	Y
5033	Minimum velocity about ECI center in meters per second.	6850	Y	Y	Y	Y
5050	Expected data interval (seconds).	1	Y	Y	Y	Y
5053	Maximum orbital period (seconds).	6420	Y	Y	Y	Y
5054	Minimum orbital period (seconds).	5250	Y	Y	Y	Y
5057	Aura clock epsilon (seconds).	0.010	Y	Y	Y	Y
5058	Data segment duration (seconds).	86400	Y	Y	Y	Y

Every ephemeris granule produced is tagged with orbit metadata. One set of orbit metadata is supplied for each orbit spanned by the ephemeris granule. Refer to Section 1.3.4 for a discussion of orbit metadata and to EOSDIS Spacecraft Ephemeris and Attitude Data Specification: Contents and Structure (P. Noerdlinger et al, 1999) for a discussion of granule header contents. This document is available on the World Wide Web at http://newsroom.gsfc.nasa.gov/sdptoolkit/appendl.html and is summarized in Release 6A.07 SDP Toolkit User's Guide for the ECS Project, Appendix L (document number 333-CD-605-003, April 2003 draft and later).

Flight Dynamics Division (FDD) Generic Data Products Formats Interface Control Document, (document number 553-FDD-91/028) provides a detailed description of the FDD ephemeris granule. In this design, the June 1991 draft was used as reference.

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3. EMOS Attitude Preprocessing

PGE EcDpPrAuraAttitudeDPREP_PGE processes the EMOS-supplied attitude data stream to produce the EMOS-supplied Toolkit attitude data stream. Two granules are produced from each EMOS attitude granule that is processed: the Toolkit and HDF-format EMOS attitude granules. Figure 3-1 highlights the flow of data during EMOS attitude data processing.

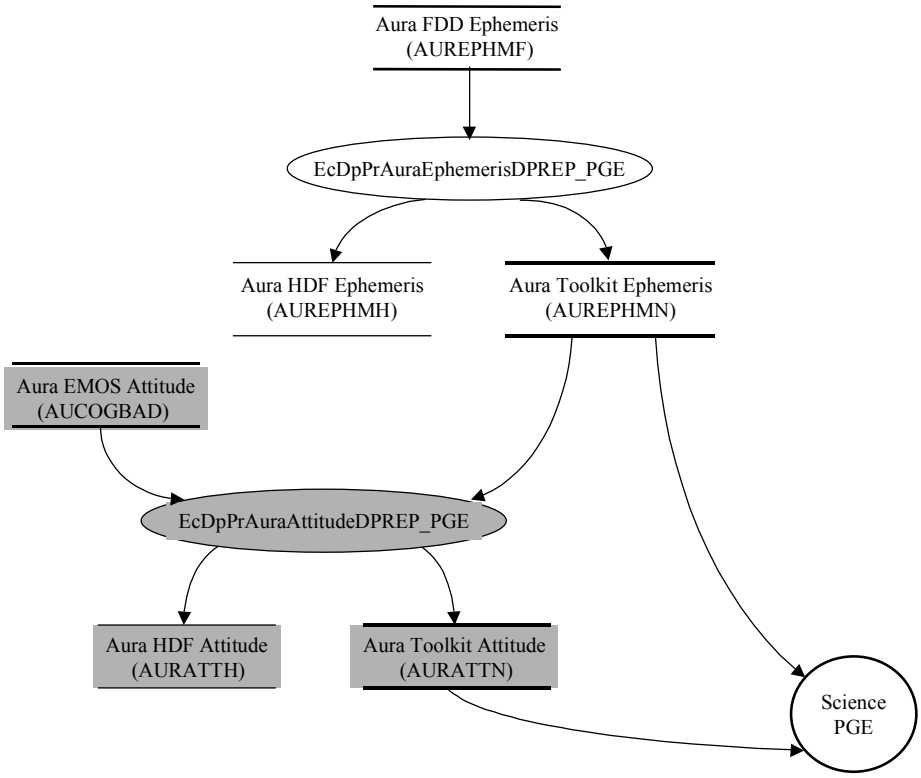

Figure 3-1. Aura DPREP EMOS Attitude Processing Data Flow

Because the attitude data are preprocessed by EMOS prior to processing by DPREP, DPREP performs minimal data quality checking on the EMOS attitude data stream. As with ephemeris data processing, the attitude data quality analyses include continuity, consistency, range, and data gap checking which are intended mainly to catch transmission errors. DPREP does not perform limit (spike) checking or data repair. Range checking confirms that Euler angles and

rates fall within the permissible range: the roll and yaw angles range from -π to π radians while the pitch angle ranges from -π/2 to π/2 radians inclusive; angle rates range from -0.005236 to 0.005236 radians per second (–0.3 to 0.3 degrees per second) inclusive. Data gaps greater than one second (one record or more) are flagged as long gaps. Consequently, all data gaps are flagged as long gaps. Any failure of data quality analysis, with the exception of long data gaps, results in entering a subscription for a replacement granule from EMOS. The replacement granule is in the same format as the original EMOS attitude granule and requires no special preprocessing by DPREP. Refer to Section 1.2.1 for a discussion of the data quality analyses performed by DPREP.

This PGE signals three exit conditions: success, failure, and data replacement required. Status code 0 indicates successful completion. Status code 200 indicates that a fatal error occurred. All downstream processing (i.e. Science PGEs) halts. Status code 216 indicates that processing completed successfully but replacement data must be requested from EMOS. Processing continues in this instance.

Table 3-1 describes the run-time parameters used in processing the EMOS attitude data. The table indicates the default value associated with the logical ID and which DPREP Profile uses the logical ID. Many of these run-time parameters control the data quality analyses performed on the EMOS attitude data stream.

Table 3-1. Aura DPREP EMOS Attitude Processing PCF Logical Ids (1 of 3)

PCF Logical ID	Description	Default	Profile ID			
			1	2	3	4
950	Spacecraft name.	EOSAURA	Y	Y	Y	Y
955	Platform indicator.	C	Y	Y	Y	Y
990	PGE version number.	None	Y	Y	Y	Y
999	Profile ID.	None	Y	Y	Y	Y
1000	EMOS attitude granule to be processed.	None	Y	Y	Y	Y
1001	Toolkit-format attitude granule file name.	None	Y	Y	Y	Y
1100	HDF-format attitude granule file name.	None	Y	Y	Y	Y
1255	Toolkit-format attitude metadata ID.	1001:1	Y	Y	Y	Y
1300	EMOS attitude granule from data segment preceding the one being processed.	None	Y	N	Y	N
1320	EMOS attitude granule from data segment immediately following the one being processed.	None	Y	Y	N	N
1800	Toolkit-format attitude granule from data segment immediately preceding the one being processed.	None	Y	N	Y	N

5009	Minimum number of consecutive missing data records required for a long attitude data gap.	1	Y	Y	Y	Y

Table 3-1. Aura DPREP EMOS Attitude Processing PCF Logical Ids (2 of 3)

PCF Logical ID	Description	Default	Profile ID			
			1	**2**	**3**	**4**
5036	Maximum angle rate in radians per second.	0.005236	Y	Y	Y	Y
5037	Minimum angle rate in radians per second.	-0.005236	Y	Y	Y	Y
5038	Ignore EMOS attitude request (0=false, 1=true).	0	Y	Y	Y	Y
5039	Euler angle order; first angle (1=X, 2=Y, 3=Z).	3	Y	Y	Y	Y
5040	Euler angle order; second angle (1=X, 2=Y, 3=Z).	1	Y	Y	Y	Y
5041	Euler angle order; third angle (1=X, 2=Y, 3=Z).	2	Y	Y	Y	Y
5042	Maximum roll angle in radians.	π [4]	Y	Y	Y	Y
5043	Minimum roll angle in radians.	$-\pi$	Y	Y	Y	Y
5044	Maximum pitch angle in radians.	$\pi/2$ [5]	Y	Y	Y	Y
5045	Minimum pitch angle in radians.	$-\pi/2$	Y	Y	Y	Y
5046	Maximum yaw angle in radians.	π	Y	Y	Y	Y
5047	Minimum yaw angle in radians.	$-\pi$	Y	Y	Y	Y
5050	Expected attitude data interval (seconds).	1	Y	Y	Y	Y
5055	Expected Status Word 2 data interval (seconds).	8	Y	Y	Y	Y
5056	Minimum number of consecutive missing data records required for a Status Word 2 data gap.	1	Y	Y	Y	Y
5057	Aura clock epsilon (seconds).	0.010	Y	Y	Y	Y
5058	Data segment duration (seconds).	7200	Y	Y	Y	Y
7960	Spacecraft position vector X component mnemonic in EMOS-supplied attitude.	GNC_SS_SCPOSECIXG	Y	Y	Y	Y
7961	Spacecraft position vector Y component mnemonic in EMOS-supplied attitude.	GNC_SS_SCPOSECIYG	Y	Y	Y	Y
7962	Spacecraft position vector Z component mnemonic in EMOS-supplied attitude.	GNC_SS_SCPOSECIZG	Y	Y	Y	Y
7963	Spacecraft velocity vector X component mnemonic in EMOS-supplied attitude.	GNC_SS_SCVELECIXG	Y	Y	Y	Y

[4] Numerically, π is 3.141592654. This is the value that will be specified in the PCF.
[5] Numerically, $\pi/2$ is 1.5707964. This is the value that will be specified in the PCF.

7964	Spacecraft velocity vector Y component mnemonic in EMOS-supplied attitude.	GNC_SS_SCVELECIYG	Y	Y	Y	Y
7965	Spacecraft velocity vector Z component mnemonic in EMOS-supplied attitude.	GNC_SS_SCVELECIZG	Y	Y	Y	Y

Table 3-1. Aura DPREP EMOS Attitude Processing PCF Logical Ids (3 of 3)

PCF Logical ID	Description	Default	Profile ID			
			1	2	3	4
7966	Attitude quaternion component 1 mnemonic in EMOS-supplied attitude.	GNC_SS_QATTIRU1G	Y	Y	Y	Y
7967	Attitude quaternion component 2 mnemonic in EMOS-supplied attitude.	GNC_SS_QATTIRU2G	Y	Y	Y	Y
7968	Attitude quaternion component 3 mnemonic in EMOS-supplied attitude.	GNC_SS_QATTIRU3G	Y	Y	Y	Y
7969	Attitude quaternion component 4 mnemonic in EMOS-supplied attitude.	GNC_SS_QATTIRU4G	Y	Y	Y	Y
7970	Attitude body rate time tag (integer portion) mnemonic in EMOS-supplied attitude.	GNC_SS_BDYRATETIN	Y	Y	Y	Y
7971	Attitude body rate time tag (fractional portion) mnemonic in EMOS-supplied attitude.	GNC_SS_BDYRATETFRG	Y	Y	Y	Y
7972	Attitude body rate X component mnemonic in EMOS-supplied attitude.	GNC_SS_BODYRATEX3	Y	Y	Y	Y
7973	Attitude body rate Y component mnemonic in EMOS-supplied attitude.	GNC_SS_BODYRATEY3	Y	Y	Y	Y
7974	Attitude body rate Z component mnemonic in EMOS-supplied attitude.	GNC_SS_BODYRATEZ3	Y	Y	Y	Y
7975	GNCC Status Word 2 mnemonic in EMOS-supplied attitude.	GNC_SS_STATWD02	Y	Y	Y	Y
10501	Toolkit-format ephemeris granule.	None	Y	Y	Y	Y

EMOS attitude processing must run at least two hours behind "real-time". DPREP consistency checks across granule boundaries and requires the EMOS attitude granule that follows the current EMOS attitude granule to perform the consistency check. Refer to Section 1.4 for more information on the DPREP processing scenario.

Refer to Interface Control Document between the EOS Mission Operations System (EMOS) and the Science Data Processing Segment (SDPS) for the ECS Project, Appendix B (document number 423-21-63, October 2001 draft or later) for more information on the EMOS-supplied attitude granule.

4. Interface Between Toolkit Granules and Data Processing Software

The following SDP Toolkit EPH tools provide the interface between the ephemeris and attitude granules, either Toolkit or HDF-format, and the science data processing software:

1. PGS_EPH_EphemAttit	Provides access to ephemeris and attitude data for a given spacecraft and set of times, interpolating the ephemeris and attitude to the specified times.
2. PGS_EPH_EphAtt_unInterpolate	Provides access to ephemeris and attitude data for a given spacecraft and time range, returning non-interpolated ephemeris and attitude.
3. PGS_EPH_ManageMasks	Retrieve and/or set the ephemeris and attitude quality flag mask values.
4. PGS_EPH_GetEphMET	Returns the orbit metadata associated with ephemeris data for a given spacecraft and set of times.

These tools are described in detail in Release 6A.07 SDP Toolkit User's Guide for the ECS Project, Chapter 6 (document number 333-CD-605-003, April 2003 draft and later).

The basis for the SDP Toolkit geolocation algorithms is described in Theoretical Basis of the SDP Toolkit Geolocation Package for the ECS Project (document number 445-TP-002-002).

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5. DPREP and the DAAC Operator

The following sections provide descriptions (or directs the reader to the source) of DPREP operational procedures, procedures for both invoking DPREP and recovering DPREP in various situations.

5.1 Running DPREP

Mission Operation Procedures for the ECS Project (document number 611-CD-600-001), Section 26.12.3, outlines the DPREP operational procedures for processing FDD-supplied ephemeris and EMOS-supplied attitude data.

5.2 DPREP Boot-up at Mission Start and After Data Dropout

Special DAAC (Distributed Active Archive Center) operator action is required to boot-up DPREP at the start of the mission or after a period of FDD-supplied ephemeris data dropout. The boot-up procedure establishes the orbit number at which PGE EcDpPrPm1FddEphemerisDPREP_PGE resumes orbit counting. The orbit number must be queried by telephoning the Flight Operations Team and requesting the orbit number that coincides with the timestamp where telemetry resumes.

When the data stream resumes after data dropout, and the first FDD ephemeris granule is ingested and archived, the operator runs the Dataserver Database Viewer (EcCoDbViewer) to determine the "Granule Details" *RangeBeginningTime* of the FDD ephemeris granule. The operator then telephones the FOT, asks to speak with the on-line engineer, and requests the orbit number at the *RangeBeginningTime* or at the time when the data segment being processed begins if the granule is truncated due to a leading long data gap. Once the orbit number is determined, the operator invokes S4PM, terminates the job requiring boot-up processing, selects *Bootstrap* processing on the job just terminated, and types-in the orbit number requested from the FOT at the *DPREP Bootstrap* GUI prompt. This informs DPREP where orbit counting is to resume. Profile 1 processing is resumed on FDD ephemeris granules thereafter.

A discussion on how to use S4PM can be found on the World Wide Web at http://daac.gsfc.nasa.gov/INTERNAL/s4pm.

5.3 Replacement Granule Subscription

Data replacement can be requested for both the FDD-supplied ephemeris and EMOS-supplied attitude data streams processed by DPREP. The procedure used to order replacement ephemeris data is virtually identical to that used to order replacement attitude data.

5.3.1 Replacement of FDD-Supplied Ephemeris Data

The DAAC operator enters a qualified subscription on the Toolkit-format ephemeris granule (ESDT short name AUREPHMN) produced from the FDD-supplied ephemeris data. The

subscription is set when the DAAC operator registers PGE EcDpPrAuraEphemerisDPREP_PGE and should be set to expire one year hence. The qualification is set on the threshold at which *QAPercentMissingData* and *QAPercentOutOfBoundsData* are to trigger data replacement. Currently this threshold is any non-zero value. This causes replacement of the FDD-supplied ephemeris data whenever a gap or range analysis violation is present. A discussion on how to use the Spatial Subscription Server GUI can be found in Section 4 of document Operational Instructions for Synergy III Utilities and GUIs (document number 300-TP-001-001).

The *RangeBeginningDateTime* and *RangeEndingDateTime* of the granule whose archive insertion triggered the replacement subscription (this is also the granule that coincides with the UR in the DAAC operator's e-mail notification that data replacement is necessary) are the times the operator should use when placing the data replacement request with FDD. The data replacement request time span is also reported by DPREP in the SDP Toolkit status log file saved in DPREP's production history.

5.3.2 Replacement of EMOS-Supplied Attitude Data

Replacement of the EMOS-supplied attitude data is achieved in a manner similar to that described above for FDD-supplied ephemeris data. The DAAC operator enters a qualified subscription on the Toolkit-format attitude granule (ESDT short name AURATTN) produced from the EMOS-supplied attitude granule. The subscription is set when PGE EcDpPrAuraAttitudeDPREP_PGE is registered and should be set to expire one year hence. The qualification is set on the threshold at which *QAPercentOutOfBoundsData* triggers data replacement. Currently this threshold is any non-zero value. This causes replacement of the EMOS-supplied attitude data whenever a range analysis violation is present. A discussion on how to use the Spatial Subscription Server GUI can be found in Section 4 of document Operational Instructions for Synergy III Utilities and GUIs (document number 300-TP-001-001).

The *RangeBeginningDateTime* and *RangeEndingDateTime* of the granule whose archive insertion triggered the replacement subscription (this is also the granule that coincides with the UR in the DAAC operator's e-mail notification that data replacement is necessary) are the times the operator should use when placing the data replacement request with EMOS. The data replacement request time span is also reported by DPREP in the SDP Toolkit status log file saved in DPREP's production history.

5.4 DPREP Failed-PGE Subscription

The DAAC operator enters a qualified subscription to either send an e-mail notification of the failed DPREP PGE and/or FTP push the failed DPREP PGE tar-file to the specified location. The DAAC operator sets the subscription when each DPREP PGE is registered. The *FailedPGEName* and *FailedPGEVersion* must qualify the subscription. The subscription should be set to expire one year hence (one year is the maximum duration for which a subscription can be set). The qualification is set on the insert of a failed PGE tar-file into the archive. A discussion on how to use the Spatial Subscription Server GUI can be found in Section 4 of document Operational Instructions for Synergy III Utilities and GUIs (document number 300-TP-001-001).

When a DPREP PGE fails, S4PM post-processing creates a tar-file that contains the PCF as well as the SDP Toolkit status log and report files. The tar-file is archived in the failed PGE ESDT (ESDT short name FAILPGE). Once the tar-file is archived, the Spatial Subscription Server completes the subscription by sending an e-mail notification and/or FTP pushing the tar-file to the specified location.

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Appendix A. DPREP Error Codes

Error Code[6]	Explanation
DPREP_E_ABORT	Announces an unsuccessful completion status of the DPREP run. Follows messages that indicate an actual problem.
DPREP_E_ADVANCE_PKT_VEC	Error returned by DPREP routine *DpPrAdvanceVector*. Follows messages that indicate the actual problem.
DPREP_E_BAD_EPHEMERIS	Failed to retrieve good ephemeris data for EVERY attitude data point processed in this data segment. Indicates ephemeris data were not generated for this data segment or PCF does not specify the required ephemeris granules.
DPREP_E_BAD_INPUT_PARAM	An invalid user-specified run-time parameter has been encountered in the PCF. Confirm that the QA window sizes are odd, positive integers, the maximum window size is greater than the minimum, Euler angle order indices range from 1 to 3, Euler angles do not consecutively repeat in the sequence.
DPREP_E_BAD_QUATERNION	The sum of squares of the quaternion components was not within the acceptable tolerance (e.g. 1.0E-07) of one.
DPREP_E_BAD_QUATERNION_ERROR	A bad quaternion was encountered while processing the EMOS-supplied attitude granule.
DPREP_E_BAD_TIME_CONVERSION	Signals a fatal error has been returned from an SDP Toolkit time conversion routine. Probably follows more informative error messages. Could indicate that a corrupted granule is being processed.
DPREP_E_CANT_CREATE_OBJ	Indicates that memory allocation failed while creating an object in C++.
DPREP_E_CANT_INIT_PKT_VECTOR	Error returned by DPREP routine *DpPrInitVector*. Follows messages that indicate the actual problem.
DPREP_E_CANT_OPEN_FDD_FILE	Could not open the FDD Attitude granule using SDP Toolkit routine *PGS_IO_Gen_Open*. Likely follows error messages that indicate the actual problem.
DPREP_E_CANT_PARSE_FDD_HEADER	Indicates that C++ routine *sscanf* failed to extract information such as granule start and end times from the FDD Attitude granule header. Could indicate that a corrupted granule is being processed.
DPREP_E_CANT_READ_FDD_HEADER	Indicates that C++ routine *fread* failed to read the FDD Attitude granule header. Could indicate that a corrupted granule is being processed.

[6] Error level meaning: "_S_" stands for success, "_A_" stands for action, "_M_" stands for message, "_U_" stands for user information, "_N_" stands for notice, "_W_" stands for warning, "_E_" stands for error, and "_F_" stands for fatal. For more information, refer to Release 6A.07 SDP Toolkit User's Guide for the ECS Project, Appendix B (document number 333-CD-605-003, April 2003 draft and later).

Error Code[6]	Explanation
DPREP_E_CANT_READ_PKT	Could not read the EDOS L0 Ancillary granule using SDP Toolkit routine *PGS_IO_L0_GetPacket*. Likely follows error messages that indicate the actual problem.
DPREP_E_CANT_READ_PROD_TIME	Failed to read the data production time from the temporary file used to pass the production time between multi-executable DPREP PGEs.
DPREP_E_CANT_READ_RECORD	Could not read the FDD attitude granule using C++ I/O routines. Likely follows error messages that indicate the actual problem.
DPREP_E_CANT_WRITE_PROD_TIME	Failed to write the data production time to the temporary file used to pass the production time between multi-executable DPREP PGEs.
DPREP_E_CARRYOUT_DATA_DUP_ERR	Duplicate data has been encountered while processing the EMOS-supplied attitude granule.
DPREP_E_CARRYOUT_DATA_ERROR	An error within the data packets of the EMOS-supplied attitude granule has been encountered. Details regarding the specific error are provided in the SDP Toolkit status log file.
DPREP_E_CARRYOUT_HEADER_ERROR	An error within the header of the EMOS-supplied attitude granule has been encountered. Indicates that a required mnemonic has not been specified in the granule header.
DPREP_E_CARRYOUT_READ_ERROR	An error has been encountered while reading or parsing the EMOS-supplied attitude granule from the current data segment. Indicates a corruption in the EMOS-supplied attitude granule,
DPREP_E_CHKSTATWORD_ERROR	An error has been encountered within the EMOS-supplied attitude granule while searching for status words that bracket the attitude to be processed.
DPREP_E_CLOSE_DATASET	Unable to close a Toolkit-format ephemeris or attitude granule being generated by DPREP.
DPREP_E_CLOSE_L0_DATASET	Indicates that SDP Toolkit routine *PGS_IO_L0_Close* failed to close the EDOS L0 Ancillary granule.
DPREP_E_CONVERT_HEADER_TIME	An error has been encountered while converting the header time found in the EMOS-supplied attitude granule to TAI93.
DPREP_E_CURHDF_WRITE_ERROR	A problem occurred while writing a record (header, data, or metadata record) to the current HDF-format ephemeris or attitude granule being created by DPREP. Could indicate any number of problems: file/directory protection violation, disk quota, etc.
DPREP_E_CURNAT_OPEN_ERROR	A problem was encountered while opening the current Toolkit-format ephemeris or attitude granule for write access. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.
DPREP_E_CURNAT_SEEKTO_ERROR	A problem occurred with a *SeekTo* function on the current Toolkit-format ephemeris or attitude granule being created by DPREP. No failure reasons can be suggested.

Error Code[6]	Explanation
DPREP_E_CURNAT_WRITE_ERROR	A problem occurred while writing a record (header, data, or metadata record) to the current Toolkit-format ephemeris or attitude granule being created by DPREP. Could indicate any number of problems: file/directory protection violation, disk quota, etc.
DPREP_E_CURR_CARRYOUT_OPEN	An error has been encountered while opening the EMOS-supplied attitude granule from the current data segment.
DPREP_E_DATA_SETFIELDS_ERROR	A problem was encountered while attempting to *VSsetfields* on fields being established in the *data* Vdata. No failure reasons can be suggested.
DPREP_E_DATA_VSATTACH_ERROR	A problem was encountered while attempting to *VSattach* to the *data* Vdata containing the ephemeris or attitude data. No failure reasons can be suggested.
DPREP_E_DATATYPE_PARAMID_ERROR	Failed to read a Data Type from the header record in an EMOS-supplied attitude granule. Indicates that the field was empty.
DPREP_E_EMOS_PARAMID_ERROR	Failed to read an EMOS Parameter ID from the header record in the EMOS-supplied attitude granule. Indicates that the field was empty.
DPREP_E_EOF_PRIOR_EODS	End-of-file was encountered prior to the end-of-granule in the FDD ephemeris granule. The sentinel flag that marks the end-of-granule was not encountered. Could indicate that a corrupted granule is being processed.
DPREP_E_ERROR	Indicates that an error was encountered in the DPREP routine that is named in the message text. Follows error messages that indicate the actual problem.
DPREP_E_FDD_DATA_ERROR	Indicates that an error was encountered while consistency checking the FDD Attitude granule header. The message text gives an explanation of the actual problem.
DPREP_E_FDD_EPHEM_READ_ERROR	A problem was encountered while reading an EPHEM-format record from an FDD ephemeris granule. Could indicate that a corrupted granule is being processed.
DPREP_E_FDD_HEADER1_READ_ERROR	A problem was encountered while reading the first header record from an FDD ephemeris granule. Could indicate that a corrupted granule is being processed.
DPREP_E_FDD_HEADER2_READ_ERROR	A problem was encountered while reading the second header record from an FDD ephemeris granule. Indicates that a corrupted granule is being processed.
DPREP_E_FDD_LO_OVERLAP	The FDD Ephemeris replacement granule overlaps the EDOS L0 Ancillary granule that follows.
DPREP_E_FDD_OPEN_ERROR	A problem was encountered while opening the current FDD ephemeris or attitude granule for read access. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.
DPREP_E_FDD_TIME_CONV_DATE	An invalid date field was encountered in the FDD ephemeris granule. Indicates that a corrupted granule is being processed.

Error Code[6]	Explanation
DPREP_E_FDD_TIME_CONV_DAYS	An invalid days field was encountered in the FDD ephemeris granule. Indicates that a corrupted granule is being processed.
DPREP_E_FDD_TIME_CONV_ERROR	Failed to convert a time field in the FDD ephemeris granule to TAI93 format. Likely follows error messages that indicate the actual problem.
DPREP_E_FDD_TIME_CONV_SECDAY	An invalid seconds-of-day field was encountered in the FDD ephemeris granule. Indicates that a corrupted granule is being processed.
DPREP_E_FILE_ACCESS	An error was encountered while reading the preceding Toolkit-format ephemeris and attitude granule. A Rogue-Wave *Read*, *Write*, or *SeekTo* function failed. Could indicate that a corrupted granule is being processed.
DPREP_E_GAPFILL_INTERP_ERROR	An error occurred during the repair of EDOS-supplied ephemeris data. Likely follows error messages that indicate the actual problem.
DPREP_E_GEN_EPHEM_REPORT	Indicates that *DpPrGenerateEphemerisReport* returned an error condition. Follows messages that indicate the actual problem.
DPREP_E_GEN_TOOLKIT	A problem has been encountered by a SDP Toolkit routine. Currently used to indicate problems with using coordinate conversion routine *PGS_CSC_J2000toTOD*.
DPREP_E_GET_FDD_UREF_ERROR	Error returned by Toolkit routine *PGS_PC_GetUniversalRef* while attempting to get the FDD ephemeris granule universal reference. No failure reasons can be suggested.
DPREP_E_GET_L0ANC_UREF_ERROR	Error returned by Toolkit routine *PGS_PC_GetUniversalRef* while attempting to get the L0 Ancillary granule universal reference. No failure reasons can be suggested.
DPREP_E_GET_NUMFILES_ERROR	Error returned by Toolkit routine *PGS_PC_GetNumberOfFiles*. No failure reasons can be suggested.
DPREP_E_GET_PRENAT_UREF_ERROR	Error returned by Toolkit routine *PGS_PC_GetUniversalRef* while attempting to get the preceding Toolkit-format ephemeris granule universal reference. No failure reasons can be suggested.
DPREP_E_GRANULE_TIMES	An error occurred while determining the predicted granule start and end times.
DPREP_E_HDF_ADD_HEADER	Error returned by DPREP routine *DpPrAddHdfHeader*. Follows messages that indicate the actual problem.
DPREP_E_HDF_ADD_RECORD	Error returned by DPREP routine *DpPrAddHdfRecord* that writes records to HDF-format ephemeris and attitude granules. Follows messages that indicate the actual problem.
DPREP_E_HDF_DEFINE_VDATA	A problem was encountered while initializing a Vdata table in an HDF-format ephemeris or attitude granule produced by DPREP. Either HDF routine *Vsfdefine* or *VSsetfields* failed. No failure reasons can be suggested.
DPREP_E_HDF_OPEN	A problem was encountered while opening an HDF-format ephemeris or attitude granule for write access. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.

Error Code[6]	Explanation
DPREP_E_HDF_OPEN_ERROR	A problem was encountered while opening an HDF-format ephemeris or attitude granule for write access. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.
DPREP_E_HDF_VSATTACH	A problem was encountered while attaching to a newly created Vdata or an existing Vdata table to be rewritten with *VSattach*. No failure reasons can be suggested.
DPREP_E_HDF_WRITE	A problem occurred while writing a record (header, data, or orbit metadata) to an HDF-format ephemeris or attitude granule being created by DPREP. Could indicate any number of problems: file/directory protection violation, disk quota, etc.
DPREP_E_HDFSD_OPEN_ERROR	A problem was encountered while connecting to the HDF-format ephemeris or attitude granule for Science Data access with *Sdstart*. No failure reasons can be suggested.
DPREP_E_HEADER_SETFIELDS_ERROR	A problem was encountered while attempting to *VSsetfields* on fields being established in the *header* Vdata. No failure reasons can be suggested.
DPREP_E_HEADER_VSATTACH_ERROR	A problem was encountered while attempting to *VSattach* to the *header* Vdata containing the ephemeris or attitude granule header information. No failure reasons can be suggested.
DPREP_E_IN_TOOLKIT_OPEN_ERROR	A problem was encountered while opening the Toolkit-format ephemeris granule undergoing data repair for read access with Rogue-Wave. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.
DPREP_E_IN_TOOLKIT_READ_ERROR	Could not read the Toolkit-format ephemeris granule undergoing data repair using Rogue-Wave. Likely follows error messages that indicate the actual problem.
DPREP_E_INITIALIZE_DATASET	A problem was encountered while initializing an HDF-format ephemeris or attitude granule Vdata table. Also associated with failing to retrieve the universal reference via SDP Toolkit routine *PGS_PC_GetUniversalRef*.
DPREP_E_INVALID_ORBNUM	An invalid initial orbit number was parsed from the PCF. No failure reasons can be suggested.
DPREP_E_INVALID_PROCESS_MODE	An invalid FDD ephemeris granule-processing mode was parsed from the PCF. No failure reasons can be suggested.
DPREP_E_INVALID_PROFILE_ID	An invalid PGE profile ID was parsed from the PCF. No failure reasons can be suggested.
DPREP_E_INVALID_SCNM	An invalid spacecraft name was encountered during DPREP processing. No failure reasons can be suggested.
DPREP_E_INVALID_VEC_SIZE	Attempted to create a data quality analysis window of an invalid length, using either an even number of points or fewer points than allowed. Could indicate a problem with the DPREP ODL, design, or code.

Error Code[6]	Explanation
DPREP_E_L0_CORRUPTED	Indicates that the buffer size is too small to hold an APID 4 L0 Ancillary granule ephemeris/attitude packet returned by SDP Toolkit routine *PGS_IO_L0_GetPacket*. The L0 Ancillary granule is likely corrupted.
DPREP_E_L0_DATA_ERROR	Indicates that a general problem occurred with SDP Toolkit routine *PGS_IO_L0_OPEN*or *PGS_IO_L0_SetStart*. Likely follows error messages that indicate the actual problem.
DPREP_E_LO_OVERLAP	The EDOS L0 Ancillary granule that is being processed overlaps the granules produced by the preceding DPREP run.
DPREP_E_LOAD_RECORDS	An error has been encountered while reading the EMOS-supplied attitude granule from the current data segment. Typically indicates a corruption in the EMOS-supplied attitude granule,
DPREP_E_LOAD_REC_ERROR	Error returned by DPREP routine *DpPrLoadAm1Record*. Follows messages that indicate the actual problem.
DPREP_E_MEM_ALLOCATION	Indicates that memory allocation failed while creating an object in C++.
DPREP_E_MET_INIT	Could not initialize the ASCII metadata file using SDP Toolkit routine *PGS_MET_Init*. Likely follows error messages that indicate the actual problem.
DPREP_E_MET_SETATTR	Could not fill a metadata into the metadata file template using SDP Toolkit routine *PGS_MET_SetAttr*. Likely follows error messages that indicate the actual problem.
DPREP_E_MET_WRITE	Could not write the metadata file template from memory to disk using SDP Toolkit routine *PGS_MET_Write*. Likely follows error messages that indicate the actual problem.
DPREP_E_META_SETFIELDS_ERROR	A problem was encountered while attempting to *VSsetfields* on fields being established in the *orbit metadata* Vdata. No failure reasons can be suggested.
DPREP_E_META_VSATTACH_ERROR	A problem was encountered while attempting to *VSattach* to the *orbit metadata* Vdata containing the ephemeris granule orbit metadata information. No failure reasons can be suggested.
DPREP_E_MISMATCH_DOY_ERROR	The day-of-year found in the EMOS-supplied attitude granule header time differs from that in the first data packet. Indicates a corruption in the EMOS-supplied attitude granule,
DPREP_E_MISMATCH_YEAR_ERROR	The year found in the EMOS-supplied attitude granule header time differs from that in the first data packet. Indicates a corruption in the EMOS-supplied attitude granule,
DPREP_E_NATIVE_ADD_HEADER	A problem was encountered while writing (or rewriting) the Toolkit-format ephemeris or attitude granule header. Also associated with failing to retrieve the universal reference via SDP Toolkit routine *PGS_PC_GetUniversalRef*.
DPREP_E_NATIVE_ADD_RECORD	Error returned by DPREP routine *DpPrAddNativeRecord* that writes records to Toolkit-format ephemeris and attitude granules. Follows messages that indicate the actual problem.

Error Code[6]	Explanation
DPREP_E_NATIVE_OPEN	A problem was encountered while opening a Toolkit-format ephemeris or attitude granule for write access. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.
DPREP_E_NATIVE_REW	A problem was encountered while rewinding the Toolkit-format ephemeris or attitude granule in preparation for rewriting the granule header.
DPREP_E_NATIVE_WRITE	A problem occurred while writing a record (header, data, or metadata record) to a Toolkit-format ephemeris or attitude granule being created by DPREP. Could indicate any number of problems: file/directory protection violation, disk quota, etc.
DPREP_E_NEXT_CARRYOUT_READ	An error has been encountered while reading the EMOS-supplied attitude granule from the following data segment. Indicates a corruption in the EMOS-supplied attitude granule,
DPREP_E_NO_MATCHING_APID	Indicates that an APID 4 data packet could not be retrieved from the L0 Ancillary granule. Probably not processing an L0 Ancillary granule or the L0 Ancillary granule does not have any APID 4 packets within.
DPREP_E_NO_NODE_CROSSINGS	Indicates that no ascending or descending node crossings were encountered in the L0 Ancillary granule being processed. A replacement FDD ephemeris granule should be requested.
DPREP_E_NODE_NUM_ERROR	Indicates that the ascending and descending node-crossing lists built by DPREP have an equal number of node crossings. Indicates a coding error in DPREP software.
DPREP_E_NOT_FDD	The FDD ephemeris granule input for processing is not an FDD ephemeris granule. No failure reasons can be suggested.
DPREP_E_NXTFDD_OPEN_ERROR	A problem was encountered while opening the following FDD ephemeris or attitude granule for read access. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.
DPREP_E_OPEN_PREV_ATT_DATA	A problem was encountered while opening the preceding Toolkit-format attitude granule. Could indicate that the incorrect DPREP profile was invoked.
DPREP_E_OPEN_PREV_EPHEM_DATA	A problem was encountered while opening the preceding Toolkit-format ephemeris granule. Could indicate that the incorrect DPREP profile was invoked.
DPREP_E_ORB_ELEM_ERROR	Unable to deduce orbital elements from position and velocity vectors.
DPREP_E_ORB_MET_INIT	A problem was encountered while initializing orbit metadata processing. Follows error messages that indicate the actual problem.
DPREP_E_OUT_TOOLKIT_OPEN_ERROR	A problem was encountered while opening the repaired Toolkit-format ephemeris granule for write access with Rogue-Wave. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.

Error Code[6]	Explanation
DPREP_E_OUT_TOOLKIT_WRITE_ERROR	Could not write the repaired Toolkit-format ephemeris granule using Rogue-Wave. Could indicate any number of problems: file/directory protection violation, disk quota, etc.
DPREP_E_OVERLAP_EPHEM_TIMELINE	An overlap between the replacement FDD ephemeris granule and the granule from the preceding or following segment was encountered.
DPREP_E_PARAMMNEMON_READ_ERROR	An error has been encountered while loading the EMOS-supplied attitude granule parameter mnemonics from the PCF.
DPREP_E_PARAMMNEMONIC_ERROR	Failed to read a Parameter Mnemonic from the header record in an EMOS-supplied attitude granule. Indicates that the field was empty.
DPREP_E_PARSE_PCF_CEPS_ERROR	An error was encountered while parsing the clock epsilon from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_CSP_ERROR	An error was encountered while parsing the collection stop time from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_CST_ERROR	An error was encountered while parsing the collection start time from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_CURHDF_ERROR	An error was encountered while parsing the name of the output HDF-format ephemeris granule from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_CURNAT_ERROR	An error was encountered while parsing the name of the output Toolkit-format ephemeris granule from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_DINT_ERROR	An error was encountered while parsing the expected data interval from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_FDD_ERROR	An error was encountered while parsing the name of the FDD ephemeris granule from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_LNGGAP_ERROR	An error was encountered while parsing the ephemeris long data gap threshold from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_MAXPOS_ERROR	An error was encountered while parsing the maximum allowed satellite distance from the ECI center from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_MAXVEL_ERROR	An error was encountered while parsing the maximum allowed satellite velocity about the ECI center from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_MINPOS_ERROR	An error was encountered while parsing the minimum allowed satellite distance from the ECI center from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_MINVEL_ERROR	An error was encountered while parsing the minimum allowed satellite velocity about the ECI center from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_NXTFDD_ERROR	An error was encountered while parsing the name of the following FDD ephemeris granule from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_ORBMAX_ERROR	An error was encountered while parsing the maximum allowed satellite orbital period from the PCF. No failure reasons can be suggested.

Error Code[6]	Explanation
DPREP_E_PARSE_PCF_ORBMIN_ERROR	An error was encountered while parsing the minimum allowed satellite orbital period from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_ORBNUM_ERROR	An error was encountered while parsing the initial orbit number from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_OUTHDF_ERROR	An error was encountered while parsing the name of the repaired HDF-format ephemeris granule from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_PGEVER_ERROR	An error was encountered while parsing the PGE version number from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_PMODE_ERROR	An error was encountered while parsing the replacement ephemeris granule processing mode flag from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_PPID_ERROR	An error was encountered while parsing the PGE profile ID from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_PREID_ERROR	An error was encountered while parsing the alternate inputs logical ID of the preceding Toolkit-format ephemeris granule from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_PRENAT_ERROR	An error was encountered while parsing the name of the preceding Toolkit-format ephemeris granule from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_SCID_ERROR	An error was encountered while parsing the FDD spacecraft ID from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_SCNM_ERROR	An error was encountered while parsing the spacecraft name from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_SDUR_ERROR	An error was encountered while parsing the data segment duration from the PCF. No failure reasons can be suggested.
DPREP_E_PARSE_PCF_TMPNAT_ERROR	An error was encountered while parsing the name of the temporary Toolkit-format ephemeris granule undergoing data repair from the PCF. No failure reasons can be suggested.
DPREP_E_PCF_FUNC_READ_ERROR	Failed to read required quantities from the PCF. No failure reasons can be suggested.
DPREP_E_PCF_ID_ERROR	A problem was encountered while parsing information from the DPREP PCF using SDP Toolkit routine *PGS_PC_GetConfigData*. Probably indicates a mismatch between the DPREP ODL and DPREP executables.
DPREP_E_PCF_READ_ERROR	A problem was encountered while parsing information from the DPREP PCF using SDP Toolkit routine *PGS_PC_GetReference*. Probably indicates a version mismatch between the DPREP ODL and DPREP executables.
DPREP_E_PGS_ECI_TO_ORB_ERROR	Could not rotate the quaternion found in the EMOS-supplied attitude granule from the ECI to orbital reference frame using *PGS_CSC_getECItoORBquat*. No failure reasons can be suggested.
DPREP_E_PGS_EPHEM_ERROR	Failed to retrieve ephemeris data for attitude data processing using *PGS_EPH_EphemAttit*. No failure reasons can be suggested.

Error Code[6]	Explanation
DPREP_E_PGS_ERROR	An error was encountered in a Toolkit routine. The offending Toolkit routine is named in the error message. Likely follows error messages that indicate the actual problem.
DPREP_E_PGS_QUATMULT_ERROR	Failed to multiply two quaternions together using *PGS_CSC_quatMultiply*. No failure reasons can be suggested.
DPREP_E_PGS_QUATTOEULER_ERROR	Failed to obtain Euler angles from a quaternion using *PGS_CSC_QuatToEuler*. No failure reasons can be suggested.
DPREP_E_PKT_BUF_SIZE_TOO_SMALL	The buffer to receive the L0 Ancillary granule header is too small. Could indicate a corrupt L0 Ancillary granule or the granule being processed is not an L0 Ancillary granule.
DPREP_E_PM_TO_TAI_ERROR	Error converting from TAI58 time to TAI93 time using *DPREP_EOSPMtoTAI*. No failure reasons can be suggested.
DPREP_E_PRENAT_DATA_READ_ERROR	A problem was encountered while reading an ephemeris data record from the preceding Toolkit-format ephemeris granule. Could indicate that a corrupted granule is being processed.
DPREP_E_PRENAT_HEAD_READ_ERROR	A problem was encountered while reading the header record from the preceding Toolkit-format ephemeris granule. Could indicate that a corrupted granule is being processed.
DPREP_E_PRENAT_META_READ_ERROR	A problem was encountered while reading an orbit metadata record from the preceding Toolkit-format ephemeris granule. Could indicate that a corrupted granule is being processed.
DPREP_E_PRENAT_OPEN_ERROR	A problem was encountered while opening the preceding Toolkit-format ephemeris set for read access. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.
DPREP_E_PRENAT_SEEKTO_ERROR	A problem occurred with a *SeekTo* function on the preceding Toolkit-format ephemeris or attitude granule being read by DPREP. No failure reasons can be suggested.
DPREP_E_PREV_CARRYOUT_READ	An error has been encountered while reading the EMOS-supplied attitude granule from the preceding data segment. Indicates a corruption in the EMOS-supplied attitude granule,
DPREP_E_PREV_FILE_PCF_ID_ERROR	An error was encountered while parsing the name of the preceding Toolkit-format ephemeris or attitude granule from the PCF. No failure reasons can be suggested.
DPREP_E_PREV_TOOLKIT_OPEN_ERROR	A problem was encountered while opening the preceding Toolkit-format ephemeris set for read access. Could indicate any number of problems: file/directory protection violation, disk quota, etc. in addition to being unable to parse the file name from the PCF.
DPREP_E_PROCESS_RANGE_ERROR	A packet/record was encountered whose timestamp falls outside the time range requested for processing. No failure reasons can be suggested.
DPREP_E_READ_COUNT_ERROR	A mismatch exists between the number of ephemeris data records read for data repair and the number that should have been read (as determined from the number stored in the Toolkit-format ephemeris granule. Could indicate that a corrupted granule is being processed.

Error Code[6]	Explanation
DPREP_E_READ_WRITE_COUNT_ERROR	A mismatch exists between the number of ephemeris data records processed during data repair and the number that have been written to the product granule. Indicates a problem in the DPREP source code.
DPREP_E_RECORD_COUNT	The number of data or orbit metadata records written does not match the number specified in the Toolkit (or HDF) format ephemeris or attitude granule header. Indicates a coding error in DPREP software.
DPREP_E_RECORD_NOT_IN_FILE	The record number of the record to be read does not coincide with a record in the Toolkit-format ephemeris or attitude granule. Could be referencing the incorrect Toolkit-format granule or the Toolkit-format file is corrupt.
DPREP_E_RECORD_ORDER_ERROR	Records in the granule being processed (L0 Ancillary, FDD Attitude, or FDD Ephemeris) are not in time order. Indicates a corrupt granule.
DPREP_E_SC_PARAMID_ERROR	Failed to read an Spacecraft Parameter ID from the header record in an EMOS-supplied attitude granule. Indicates that the field was empty.
DPREP_E_TMP_CLOSE	A problem was encountered while closing the temporary Toolkit-format ephemeris granule. Could indicate any number of problems: file/directory protection violation, disk quota, etc.
DPREP_E_TMP_OPEN	A problem was encountered while opening the temporary Toolkit-format ephemeris granule for write access. Could indicate any number of problems: file/directory protection violation, disk quota, etc.
DPREP_E_UNEXPECT_RUNTIME_ERROR	A problem was encountered with a try-catch block. The try-catch block is typically used when allocating memory for arrays internal to DPREP. No failure reasons can be suggested.
DPREP_E_UNKNOWN_SWITCH_ELEMENT	A problem was encountered while trying to find a match between a switch statement argument and one in the recognized element list. No failure reasons can be suggested.
DPREP_E_UNKNOWNSATELLITE	A problem was encountered while trying to find a match between a satellite platform requested for processing and one in the recognized platform list. No failure reasons can be suggested.
DPREP_M_BEGIN	Signals the beginning of a DPREP run.
DPREP_M_DATA_FILLED	States the number of records that were generated while filling data gaps in the EDOS ephemeris data stream.
DPREP_M_DATA_FILLED_REPAIRED	States the number of records that were generated while filling data gaps and the number that were repaired in the EDOS ephemeris data stream.
DPREP_M_DATA_REPAIRED	States the number of records that were repaired in the EDOS ephemeris data stream.
DPREP_M_END	Signals the termination of a DPREP run.
DPREP_M_PROCESS_TIMES	States the beginning and ending times of the interval requested for processing by DPREP.
DPREP_M_QA_SUMMARY	Signals the accompanying QA analysis summary.

Error Code[6]	Explanation
DPREP_N_INVALID_STATWORD	An invalid Status Word 2 value has been encountered in an EMOS-supplied attitude granule.
DPREP_N_INVALID_STATWORD_ERROR	DPREP routine *FindStatusWord* has encountered an invalid Status Word 2 value in an EMOS-supplied attitude granule.
DPREP_N_NEXT_CARRYOUT_OPEN	An error has been encountered while opening the EMOS-supplied attitude granule from the following data segment.
DPREP_N_NEXT_CARRYOUT_READ	An error has been encountered while reading the EMOS-supplied attitude granule from the following data segment. Indicates a corruption in the EMOS-supplied attitude granule,
DPREP_N_NOTICE	A general notification message with specific information imbedded within the message text.
DPREP_N_PREV_CARRYOUT_OPEN	An error has been encountered while opening the EMOS-supplied attitude granule from the preceding data segment.
DPREP_S_SUCCESS	Announces successful completion of the DPREP run.
DPREP_W_BAD_DATA_FIT	DPREP routine *DpPrLeastSquaresFit* failed to perform a quadratic least-squares fit to data in the QA window in preparation for a limit check. Likely follows error messages that indicate the actual problem. The specified data packet will be flagged for failure of QA analysis.
DPREP_W_BAD_STATUS_WORD	The Status Word 2 retrieved from the preceding or following EMOS-supplied attitude granule indicates an unrecognized attitude mode.
DPREP_W_BEGIN_PROJECT_ORBIT	Indicates that DPREP has found a long data gap in the ephemeris timeline that spans one or more node crossings, and is preparing to extrapolate orbit metadata across the gap. DPREP uses the orbital period and descending node propagation from the last available segment or those determined from the current ephemeris granule with which to extrapolate orbit metadata.
DPREP_W_CALC_NODE_PROP	Failed to determine the descending node propagation. Indicates a DPREP coding problem.
DPREP_W_CALC_ORB_PERIOD	Failed to determine the orbital period. Indicates a DPREP coding problem.
DPREP_W_CANT_CHECK_POS_VEL	DPREP routine *DpPrLeastSquaresFit* failed to perform a quadratic least-squares fit to position and velocity vectors in the QA window in preparation for a limit check. Likely follows error messages that indicate the actual problem. The specified data packet will be flagged for failure of QA analysis.
DPREP_W_CANT_CHK_ANGLE	DPREP routine *DpPrLeastSquaresFit* failed to perform a quadratic least-squares fit to Euler angle data in the QA window in preparation for a limit check. Likely follows error messages that indicate the actual problem. The specified data packet will be flagged for failure of QA analysis.
DPREP_W_CANT_CHK_ANGLE_RATE	DPREP routine *DpPrLeastSquaresFit* failed to perform a quadratic least-squares fit to angle rate data in the QA window in preparation for a limit check. Likely follows error messages that indicate the actual problem. The specified data packet will be flagged for failure of QA analysis.

Error Code[6]	Explanation
DPREP_W_CANT_CHK_DATA	An error occurred while performing a quadratic least-squares fit to data found in the QA window. Likely follows error messages that indicate the actual problem.
DPREP_W_CANT_CHK_POS	DPREP routine *DpPrLeastSquaresFit* failed to perform a quadratic least-squares fit to position data in the QA window in preparation for a limit check. Likely follows error messages that indicate the actual problem. The specified data packet will be flagged for failure of QA analysis.
DPREP_W_CANT_CHK_VEL	DPREP routine *DpPrLeastSquaresFit* failed to perform a quadratic least-squares fit to velocity data in the QA window in preparation for a limit check. Likely follows error messages that indicate the actual problem. The specified data packet will be flagged for failure of QA analysis.
DPREP_W_CONT_MISSING_PKTS	A long data gap has been found in the data. Indicates that a replacement granule that spans the specified time interval is necessary.
DPREP_W_END_PROJECT_ORBIT	Indicates that DPREP has found a long data gap in the ephemeris timeline that spans one or more node crossings, and has completed extrapolating orbit metadata across it. DPREP uses the orbital period and descending node propagation from the last available segment or those determined from the current ephemeris granule with which to extrapolate orbit metadata.
DPREP_W_EPHEM_QA_ERROR	Encountered ephemeris data with poor data quality thereby making the ephemeris unusable for processing attitude data.
DPREP_W_EST_ORBIT_PERIOD	Indicates that the orbital period that was determined by examining the node crossings that were found in the ephemeris data stream was questionable. The orbital period taken from the preceding Toolkit-format ephemeris granule header, or calculated from the current ephemeris granule, was used instead.
DPREP_W_FDD_END_OF_DATASET	The end-of-granule has been reached on the FDD Attitude granule. This condition is never signaled in the SDP Toolkit status log file.
DPREP_W_FLAGGED_DATA_REMAINS	Non-repaired ephemeris data remains in the EDOS ephemeris data stream. There were an insufficient number of ephemeris data points available with which the data repair could be achieved.
DPREP_W_HIGH_RED_EXCEEDED	Indicates that a red high limit or range violation occurred in the specified data stream. The specified data packet will be flagged accordingly.
DPREP_W_HIGH_YELLOW_EXCEEDED	Indicates that a yellow high limit or range violation occurred in the specified data stream. The specified data packet will be flagged accordingly.
DPREP_W_INSUFFICIENT_POINTS	Indicates that DPREP was unable to populate the QA window with the minimum required number of data packets. The specified data packet will be flagged for failure of QA analysis.
DPREP_W_INVALID_CARRYOUT_STATUS	An error within the data packets of the EMOS-supplied attitude granule has been encountered. Details regarding the specific error are provided in the SDP Toolkit status log file.
DPREP_W_L0_FILE_WARNING	Indicates a potential corruption of the EMOS-supplied L0 Ancillary granule.

Error Code[6]	Explanation
DPREP_W_LONG_GAP_END	Indicates that a long data gap ended at the specified time. The specified data packet will be flagged accordingly.
DPREP_W_LONG_GAP_FOLLOWS	Indicates that a long data gap began at the specified time. The specified data packet will be flagged accordingly.
DPREP_W_LOW_RED_EXCEEDED	Indicates that a red low limit or range violation occurred in the specified data stream. The specified data packet will be flagged accordingly.
DPREP_W_LOW_YELLOW_EXCEEDED	Indicates that a yellow low limit or range violation occurred in the specified data stream. The specified data packet will be flagged accordingly.
DPREP_W_MISSING_DATA	Indicates that at least one data packet was found missing in the timeline being analyzed. Data repair will be performed if the missing packet was found in the EDOS-supplied ephemeris timeline. Otherwise, data replacement will be requested from FDD via the Spatial Subscription Server.
DPREP_W_MISSING_STATUS_WORD	An attitude record at the specified timestamp has been flagged because a bracketing Status Word 2 packet is missing from the Status Word 2 timeline.
DPREP_W_NEXT_PROFILE_CHANGE	The profile used in DPREP processing was changed due to the unavailability of a granule from the following data segment. The granule did not become available within the wait period. The original and newly assumed profiles are displayed by this message.
DPREP_W_NO_ORBITAL_ELEMENTS	None of the orbital elements that were calculated by routine *ECS_Get_Orbital_Elements* describe an ellipse or circle. Unable to estimate orbital elements.
DPREP_W_NO_OUTPUT_GEN	Indicates that neither ephemeris and attitude data were requested for production when processing the EDOS L0 Ancillary data.
DPREP_W_NOT_ELLIPSE_OR_CIRCLE	Some of the orbital elements calculated by routine *ECS_Get_Orbital_Elements* do not describe an ellipse or circle.
DPREP_W_PREV_PROFILE_CHANGE	The profile used in DPREP processing was changed due to the unavailability of a granule from the preceding data segment. The granule did not become available within the wait period. The original and newly assumed profiles are displayed by this message.
DPREP_W_RANGE_VIOLATION	Data range violations found in the data. Indicates that a replacement granule that spans the specified time interval is necessary.
DPREP_W_SAFE_MODE	Indicates that a safe-mode-flagged record was encountered at the specified time in the EMOS data stream. The specified data packet will be flagged accordingly.
DPREP_W_SHORT_GAP_END	Indicates that a short data gap ended at the specified time. The specified data packet will be flagged accordingly.
DPREP_W_SHORT_GAP_FOLLOWS	Indicates that a short data gap began at the specified time. The specified data packet will be flagged accordingly.
DPREP_W_SHORT_GAP_REMAINS	A short data gap remains in the EDOS ephemeris data stream. There were an insufficient number of ephemeris data points available with which the gap-fill could be achieved.

Error Code[6]	Explanation
DPREP_W_SINGULAR_MTRX	Indicates that a singular matrix was encountered while solving the quadratic least-squares fit to the QA window. The data packet undergoing QA will be flagged for failure of QA analysis.
DPREP_W_USING_DEFAULT_ORBIT	Indicates that DPREP is using the 'default' orbital period and descending node propagation in orbit metadata projection. This follows from having failed to find two consecutive ascending or descending node crossings from which to calculate these quantities. The 'defaults' are taken from the last available segment or calculated from the current ephemeris granule.

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Abbreviations and Acronyms

Aura	EOS Project afternoon spacecraft series; HIRDLS, MLS, OMI, and TES instruments; formerly CHEM
AMPT	Automated Maneuver Planning Tool
ASCII	American Standard Code for Information Interchange
CCSDS	Consultative Committee for Space Data Systems
CHEM	EOS Project afternoon spacecraft series; HIRDLS, MLS, OMI, and TES instruments
CSC	Coordinate System Conversion
DAAC	Distributed Active Archive Center
DP	Data Processing
DPREP	Data Preprocessing
ECI	Earth Centered Inertial
EMOS	EOS Mission Operations System
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
ESDT	Earth Science Data Type
FDD	Flight Dynamics Division (GSFC Code 550)
FDS	Flight Dynamics Systems
FOT	Flight Operations Team
FTP	File Transfer Protocol
GNCC	GN&C Controller
GN&C	Guidance, Navigation, and Control
GSFC	Goddard Space Flight Center
GTDS	Goddard Trajectory Tracking System
HDF	Hierarchical Data Format
J2000	Mean Celestial Reference Frame at JD 2451545.0 TDT (2451545.0 is noon, not midnight, and is equivalent to 2000-01-01T11:58:55.816 UTC)
JD	Julian Date (days from noon, 4713 BC)

JD (in TDT)	JD (in UTC) plus cumulative leap seconds plus 32.184 seconds
MCF	Metadata Control File
ODL	Object Description Language
PCF	Process Control File
PGE	Product Generation Executable
QA	Quality Assurance
S4PM	Simple Scalable Script-based Science Processor for Missions
SDP	Science Data Processing
SDSRV	Science Data Server
tar	UNIX term derived from "tape archive"
TAI	Temps Atomique International (International Atomic Time)
TDT	Terrestrial Dynamical Time
TK	Toolkit
TOD	True-of-Date
UR	Universal Reference
UTC	Coordinated Universal Time
Vdata	A framework for storing customized data tables in HDF files